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TRAVEL

Address to the Geographical Association

Professor F. Debenham, O.B.E.
President, 1952

I AM very conscious of the fact that the subject I have chosen for my presidential address is not in the tradition of the past. I cannot emulate those of my distinguished predecessors who have given you a discourse on the progress of Geography or have presented a skilful analysis of its scope and content. I realise too, with some dismay, that after half a life-time occupied in teaching geography, I have no advice to give on that subject which is not either common knowledge or out of date. Therefore I fall back upon a topic which is at least fundamental to our profession since travel, either our own or that of others, is the very essence of geography.

I am using the word in its most elastic sense and indeed the charm of travel is that it is always relative. You can choose between the extremes of a Kontiki voyage and a trip by bus to the seaside. Both are travel. We know well enough that there are some who have got far more from travels with a donkey than others from a voyage round the world in a luxury liner.

What a blessing to mankind is this almost universal urge to travel and an added delight is that it can be satisfied to some extent when done by proxy, with the aid of imagination. In fact, both at the beginning of life and at its latter end, that form of travel—armchair travel—is the normal one, and a highly satisfactory form it is. It is far more comfortable than real travel and can be just as exciting as your imagination likes to make it.

I firmly believe that many geographers are born when, at the age of nine or thereabouts, they first curl up in an armchair with a story of travel. They can, so quickly, come to regard the book as a magic casement through which, at will, they can gaze upon, not only perilous seas and faery lands forlorn, but tropic isles and pirate lairs and of course lions and tigers galore. In my day it was Ballantyne and Fennimore Cooper who proffered us this fanciful fare but nowadays the choice of subject and author is far wider.

For old age, with its deeper insight and its broader experience, the range is almost unlimited both in time and space—from Herodotus to Heyerdahl and from the poles of the earth to the summit of Everest. There may be a certain nostalgia in such reading and regret that rheumatic joints forbid any further share in adventurous travel, but for the under-ten there is all life ahead and all the joy of pretence that there is adventure waiting round the next corner.

I call to mind a small boy, living in a sordid gold-mining township in the back-blocks of Australia, who never returned from the bottom

end of the long garden at night without imagining a tiger leaping the fence after him. He always won the back door by a thrillingly narrow margin and would bang it hard in the face of the tiger. He had not then heard of the valiant Tartarin of Tarascon, who, in excess of lion-mania, would swing back his suburban garden-gate violently every night, exclaiming " Ah, had a lion dared to be there what a mess (*quelle marmalade !*) I would have made of him ! "

The same small boy had his first disappointment about travel when he struck up a friendship with a hoary old sinner of a gold digger. This old Scot used to pan the silt in the stream near the house on the offchance of finding a " glitter " and thereby the price of a drink. Earnest questioning one day established the fact that the old man had never seen either a lion or a tiger but he had once lived on a coral island, if that would do instead. Here indeed was the golden door of romantic travel wide open for the entering, but alas, all the questions fired at the doorkeeper elicited no more information than that a coral island was " round-like " and made of coral and suffered from a deplorable lack of some substance called " Whusskey."

Even the small boy knew that there ought to be more to say than that about a coral island even if it couldn't quite run to pirates. That was his first meeting with the blind—and dumb—type of traveller. He met many later on but none quite so bad as the alleged American who said " Rome ? Rome ? Wasn't that where I bought those bad cigars ? " And that perhaps is the first lesson a young geographer should learn about travel, that he must be able to describe what he sees.

The romantic side of travel has its natural appeal for the young and fortunately the appeal dies hard, but here we are dealing with travel for grown-ups. We must therefore take it seriously and not merely on the basis of rolling down to Rio just because there are armadilloes there. We must also be careful that we do not confuse mere roaming with travel, pleasant as roaming may be. We geographers, at all events, do not travel just to " see the world," or if we do we may be just as dissatisfied with it as were the Americans in the popular song who joined the Navy to see the sea.

Rudyard Kipling balanced his many services to geography by one great disservice. That was his glorification of the wanderer, the men of the legion that never was 'listed, the hoboes of the world. In one of his ballads about this Tramp Royal as he called him elsewhere, he gives a reason for such roaming :

" For to admire an' for to see,
For to be'old this world so wide—"

which is an excuse rather than a reason, the real reason appearing most ungrammatically, in the last line :

" But I can't stop it if I tried."

It is difficult to imagine a geographer indulging in aimless travel yet I for one must confess to having gone to a place because I liked its name or on some equally futile pretext, though I may have found a purpose when I reached it.

On the other hand it is possible to be too earnest about one's purpose in travelling and to forget that one can study a country in its *biergartens* or at sundowner parties nearly as profitably as at its Department of Statistics. There was a very notable traveller of last century who tended to err in that direction. This was none other than Lady Jane Franklin, wife and widow of Sir John Franklin. It was her habit not only to visit every important feature, architectural or natural, in every town she reached, but also to copy down in her diary in full whatever the local guide-books said about it, to the infinite weariness at times of both her companions of the day and her biographers of the morrow.

So it comes to this, that a geographer wants to travel because he has the divine urge to do so, but his urge makes him want to travel intelligently and with a plan or for a purpose. Is it possible for those of us who have had some experience of travel to offer any advice to the younger generation ?

The trouble with advice is that unless it is actually asked for it is usually unwelcome and it is often directed to the wrong person. A very eminent geologist was once the principal guest of the Cambridge Geographical Club at its annual dinner. For some reason he had made up his mind that the club was about to explore Africa, whereas at that time they were more interested in the polar regions. The burden of his speech therefore was that whatever else you did you must have a bath every night in Africa and that the water must be boiling hot. You could forget the soap, you could lose the quinine, you could abandon the mosquito netting but you must not forget to have a hot bath every night. I fear that ten minutes on this sole theme convinced the Club not only that it wouldn't dream of travelling in Africa but also that if it did, it would try a cold bath just to see what happened, the illustrious speaker having forgotten to say that the point of the water being hot was to scotch the *Bilharzia* germs.

I am not therefore offering any advice as to travel but merely making some observations, based chiefly on having done the wrong thing myself at some time or other.

My first observation concerns the rate of travel and that includes, of course, the means of travel. In my opinion it is best to do your travelling as slowly as possible. Fly, if you like, to the scene of operations, but once there adopt the slowest means of getting about ; Shanks's ponies by preference. If you must have transport of some kind let it be a donkey rather than a bicycle, a bicycle rather than a car, a car rather than a train, and an aeroplane never at all. It means a great reduction in the area covered of course, but, I think, a greater value in the study you are making. Having raced over a good part of Africa in lorries and motor launches, I now realise that I should know that continent far better had I covered but one tenth of the distance by ox-waggon and dug-out canoe.

The next observation I would offer is that it always wise to travel comfortably, which is an entirely different thing from travelling in

luxury. It means things like taking pains to get a good night's sleep, or stopping before you are dead tired, or even making sure you have a supply of Keating's powder. In more primitive travel it means spending more time in pitching your camp or more care in the selection of the provisions you take. I shall always remember an instance of this which the late Dr. C. T. Madigan of South Australia told me. He was travelling in Central Australia and he occasionally camped with or near cattle-men. He described the utter scorn of these men when they found that he used to sit on a log for his meal instead of kneeling on the ground with one knee and sitting on the other heel as they do, and also because he took jam to spread on his dry damper. The cattle-men rolled into their blankets as soon as the evening meal was over whereas Madigan still had two or three hours work to do on his notes and specimens. In fact he could not afford to live uncomfortably, or his work would have suffered. The same thing is even more true of polar travel but that is a very specialised form of enjoyment and need not detain us here.

The seasoned traveller is always prepared to live hard and go short if necessity arises, but he keeps a careful watch on that border line beyond which hardship entails inefficiency.

Now we come to an observation which I would not trouble to make were it not that I have actually heard the matter argued. Some would say that it is better to approach a new country with a fresh untrammelled mind without any preconceived notions concerning it, and that, as a corollary, it is unnecessary to read books on it or study maps.

This I hold to be quite an unnatural and ungeographical attitude to take towards travel; in fact I would say that the better informed a man is before he visits a country, the more he will appreciate it; and certainly he will cause less annoyance to the local inhabitants who will not have to answer so many silly questions. I think that most of us could quote instances where fore-knowledge of what one was about to see was very helpful and timesaving; here I will quote one which was slightly embarrassing but amusing.

Captain Scott's ship, the *Terra Nova*, was steaming along close to land making for its base, when two of the seamen were having a great argument as to which of two valleys led up to the plateau, the curious thing being that both of them had been up there on Scott's first expedition. One of the scientists, a newcomer, had so carefully memorised the maps and narratives of previous visitors that he was able to tell the old hands which was the right valley, and give due reasons. Thereupon one of them said, " Excuse me for the asking, Sorr, but was you here with Mr. Shackleton by any chance?" The answer being in the negative, he went on, " Well, Sorr, I reckons you knows your navigating and I hopes as how I'll be on your sledge-party."

Returning to the subject of the young geographer about to travel, I would suggest that the most useful accomplishment he can cultivate

is sketching. It may show how out-of-date my methods of teaching geography are, but I think that, were I once more a school-master teaching the subject, I would make my pupils not only draw maps but draw monsters on them to fill the gaps, in the medieval style. If that were allowed, then, instead of awarding punishment of a hundred lines, any culprit would have to draw a hundred elephants or any other animal with four legs, legs being the " Achilles' heel " of amateur artists.

Why this insistence upon an accomplishment which is fast disappearing and which is so tedious and inaccurate compared to even the most moderate photography ? There are two reasons. One of them is that it is only when you sketch a thing, be it a mountain or a cathedral, or a native hut, that you really take in its details and appreciate it fully. To my mind the artist is the most skilled observer there is and to observe with care is the duty of every geographer.

The other reason is that in sketching you can, and do emphasize those features which are of special interest, whereas a photograph reproduces every detail with a like definition so that every one of them appears to have an equal importance. It seems well-nigh impossible to get a photographer, a professional photographer, to take a distant landscape without putting a pretty girl in the foreground, preferably on a horse and pointing dramatically at nothing in particular. The artist-geographer would never stoop to such frivolity ; he would make those features prominent in his drawing which were prominent in his mind as he viewed them.

I can quote a good instance of this, greatly to my own discredit. Coming for the first time to the rim of the Grand Canyon of the Colorado, I was dumbfounded, like everyone else, with its vast size and its rich confusion of detail in landforms. Mesas, buttes, pyramids, sphinxes, cathedral spires, towers and battlements stretch out before you in utter embarrassment to eye and mind. With a vague idea of taking all this scene away with me to study at leisure I spent ten minutes taking a series of panoramas with my miniature camera, not even pausing to reflect that I could get far better ones from the drug-store behind me for half a dollar. The final result, even when enlarged and carefully mounted, is still a confusion and an embarrassment and from it I could not, for the life of me, tell you which is the Coconino sandstone and which is the Redwall limestone. Had I spent half an hour sketching one small section of the landscape, I could at least give you that information since they would have been labelled. I might even have been able to venture an opinion as to why Cheops Pyramid is so named when it is half the world away from that gentleman's homeland.

Not that I would decry the value of photography as an aid to geography ; far from it, and in many circumstances nothing can take its place, especially now that colour photography is so simple and so accurate. Sketching and photography are in fact complementary to each other.

If you are prepared, as I am, to offend all the canons of true art in the sacred cause of science, you can even combine the two in a most effective way. You take your photograph and afterwards you make a lightning sketch, outlining and naming those features which you wish to take prominence. Later you take an enlargement of your photograph and trace over those same features with waterproof ink. The result looks awful until you dip the photograph into a bleaching solution, after which you will feel that after all you are not such a poor hand at sketching as you thought you were.

In sober truth neither the sketch nor the photograph gives the geographer-traveller quite all he wants, since they give the scene from one viewpoint only. You cannot turn the perspective round to see what it looks like from the other direction, as you can with a map. It goes without saying that the geographer always begs, borrows, steals, or even buys whatever topographic maps are to be had of the country in which he is travelling. They are not only his most truthful guides but they are never tongue-tied or too verbose, as is apt to be the case with human guides.

In this age of cold wars and universal suspicion, one must not flourish such maps about too much, even when they have been bought publicly in the market-place, so to speak. In 1914 I was going out to Australia for the British Association meeting there and had the great good fortune to become friendly with that giant of geomorphology, Professor Albrecht Penck. He had a wonderful set of large scale maps of the Suez Canal, bought from the authorities in Port Said, and he and I sat up in the bows of the ship while daylight lasted, identifying features as we passed them. That night we had news of the Serajevo bomb, and a month later the poor man was put under open arrest in Australia on the information of a ship's officer concerning those maps of the Suez Canal.

But the ordinary topographic maps are often inadequate and on too small a scale for the geographer's special needs. Consequently it is my humble submission that he should be able to make his own. This is a delicate subject to put before a body of expert geographers and I am fully conscious of being notorious for my devotion to map-making at all levels of precision, the higher levels being admittedly a job for specialists beyond the technique of ordinary working geographers. So I hasten to say that this suggestion has nothing to do with adding theodolites to your baggage, or indeed any instruments at all, for it is merely that there is much to be said for cultivating the knack of making sketch-maps entirely by eye, that is, by estimation and judgment.

In practice it means altering the perspective you are viewing into a plan such as would be seen from an aeroplane, and it is much easier to do than one would imagine, provided the area is small and one has a reasonably good view of it. The essential feature of such sketch-maps is the multitude of form lines you put on them, for it is usually the

relief of the area you want to portray, even if your actual object is only the lay-out of a village.

The intrinsic value of each sketch-map may be quite negligible. I must have drawn many thousands of such maps but I cannot recall using more than a score or so for reproduction. The real value to the geographer lies in the making of the map ; for the very act of transferring to paper the relief or the distribution in that way fixes the attention on features which otherwise would pass unnoticed. Further, even the roughest of sketch-maps serves as a useful aide-memoire to the mapper, however much it may appear to be gibberish to everyone else. In self defence I would plead that sketch-mapping by eye was a standard practice with such stalwarts as William Morris Davis and T. Griffith Taylor.

I once ventured to write half a book on the art of plane-table mapping and was discussing it with the late Brigadier Winterbotham. He had written a much better one himself and, as some of you will remember, he had a genial but nevertheless masterful mode of expressing his opinion. He said, in effect, " No need to write all that stuff, just give a man a plane table and send him out into the field ; he'll learn to know country all right." In the main I agree, but I think I would add a corollary : " Of course, he would learn still more quickly and cheaply if he just made sketch-maps by eye."

Let us turn now from these rather technical matters to the broader principles involved in a geographer's travel. It is almost a trite observation to say that he usually tries to cover too wide a field ; I have always done so myself. The tendency is to persuade oneself that where all is new and interesting one must study all ; Place, Work, People and anything else that may be missed by those categories. We know well enough what a varied field of sciences the geographer must wander into and at least keep some sense of direction ; but he cannot cover all that territory any more than he can visit every nook and cranny of the country of his choice.

Our intelligence—and our life-span—being limited, it is necessary for the geographer to specialise in some degree ; to single out one aspect of what he sees for special study. He can observe all the facts he has room for in his mind but he had better reserve only a small set of them for explanation, deduction and correlation. If he is as canny in his selection as I have been, he will choose for his specialism some small and simple study such as Water Resources which every one can help him with. The only sure guide to his choice, however, must be that he is dead keen on that branch of his subject.

The fascination of travel for a geographer is that although he always has his special study at the back of his mind he can also enjoy, with all the ordinary travellers, the sights, sounds and smells of travel ; perhaps we should also add the " eats." He can stand spellbound with amazement before the ruins of Baalbek and yet have room in his mind to inquire how the builders managed their water supply and their sanitation. He can struggle through Malayan rain-forest to see a

Saki encampment and yet theorise to himself as to whether there is a causal connection between pigmies and tropical jungle. He can cross the broad Kalahari all agog at the wealth of animals and birds he is seeing and yet pause to consider what might be done with such quantities of sand.

Yet we must beware of hypocrisy in this matter of how a geographer travels and how much more he gets out of it because he has a purpose. That is true enough but in the long run he will probably remember best those sights and sounds and smells of foreign lands.

I realise this very fully as I sit writing this address in a small hut in a somewhat remote part of Central Africa. I know quite well that my most lasting memories of this place will not be the granitic structure of the district nor its challenging pattern of drainage, nor even the incidence of violent tropical thunderstorms which so often defeat my thatched roof. Long after those have faded I shall be remembering the green mamba I failed to kill the other day or my efforts to tame my pet chameleon, Albert, or the sound of the piccanins' song as they top the tobacco plants, or the taste and smell of the mangoes I see being brought in.

Even though the geographer, like the artist, has the ability to see more than others on his travels because he has cultivated special faculties for seeing, he will, I hope, remain a normal person. Though his work will give him infinite satisfaction his keenest pleasure in travel will still come through his senses. Travel to a geographer should be a richer experience than it is to other people ; therefore in bringing this rambling discourse to an end I would like to give you the traveller's farewell—Bon Voyage, Good Travelling to you all.

A BATHYMETRICAL STUDY OF LLYN CAU, CADER IDRIS

G. M. Howe and R. A. Yates*

AN interesting survey operation was carried out by a party of students from the Department of Geography and Anthropology, University College of Wales, Aberystwyth, on the 6th and 7th October 1951. Under our direction they spent two complete days making a comprehensive series of soundings, levels, and a compass traverse of the corrie lake, Llyn Cau, on the southeast slopes of Cader Idris, Merionethshire. The project was carried out under most favourable conditions, the weather being beautifully calm, and apart from a few hours during the afternoon of the 6th, not a ripple disturbed the surface of the lake.

* Mr. Howe and Mr. Yates are members of the staff of the Department of Geography and Anthropology, University College, Aberystwyth.

T. J. Jehu,[1] in 1900, ascertained the configuration of some 15 lakes in North Wales, but he confined his attention to Snowdonia and East Caernarvonshire, as did Brend[2] in 1897 and Marr and Adie[3] in 1898. Until 1951 when Miss Ferrar sounded Bala lake,[4] no subsequent work on these lines had been carried out in Wales and so, Llyn Cau, one of the finest corrie lakes in Britain, remained unplumbed. Under-water details of other corrie lakes in Central Wales are as yet unknown. W. V. Lewis, a recognised authority on glacial erosion considers Cwm Cau, wherein rests Llyn Cau, as one of the finest of cirques,[5] and it was for this reason that Llyn Cau was chosen for the exercise. As a result of the survey, significant details have been added to Jehu's Inventory (Tables 1 and 2), and an accurate large-scale plan of the outline of the lake showing sub-aqueous contour lines has been made (Fig. 4). From this plan and the results of running lines of levels across the morainic material damming the lake and up the scree face bordering the steep head wall, numerous sections have been constructed (Fig. 5).

Llyn Cau

Llyn Cau lies in a rocky amphitheatre on the southeast side of Cader Idris (Fig. 1) at a height of approximately 1,550 feet O.D., and is thus described by Lewis :

> It is surrounded on three sides by rock walls varying between 1,000 feet and 1,500 feet in height (see Figs. 5E & 5F). The east-facing head wall and the southern slopes consist of the Upper Acid division of the Llandeilo Series which dip steeply to the south. These beds consist of a complex series of ashes and lavas of intermediate to acid composition with occasional intercalations of slaty material, all of which have been more or less affected by silicification. The vertical nature of the head wall suggests that the series is highly resistant. Running east-west and occupying most of the floor of the cirque are 500 feet of grey-blue Llyn Cau Mudstones. They show strong cleavage and probably present a line of weakness along which the cirque has been excavated, for the headwall is both lowest and least precipitous where these beds crop out on either side of the indistinct pathway leading to Bwlch Cau. The cirque floor is, however, considerably more extensive than this outcrop and transgresses particularly on to the pillow lavas of the Upper Basic Group which lie to the north. The cliffs on the north side, rising over 1,500 feet to Pen y Gader, closely follow the dip slope of this group and are less precipitous than either those at the head or those on the south side (Fig. 2).

The outlet of the lake is towards the east by a streamlet which first flows over a series of step falls fashioned in glacially striated and smoothed rocks to the hanging junction with the main valley, and then rushes down the steep valley side to Tal-y-llyn.

Method

All the soundings were taken from a large rubber dinghy. No boat was available on Llyn Cau and the deflated dinghy, together with

[1] T. J. Jehu, " A Bathymetrical and Geological Study of the Lakes of Snowdonia and Eastern Caernarvonshire." *Trans. Roy. Soc. Edin.*, vol. xl, pt. 11, for Session 1901–2, p.419–467.

[2] W. A. Brend, " Notes on Some Lakes of Caernarvonshire," *Geol. Mag.*, vol. 4, 1897, p.404 *et seq.*

[3] J. E. Marr and R. H. Adie, " The Lakes of Snowdon," *Geol. Mag.*, vol. 5, 1898, p.51 *et seq.*

[4] A. M. Ferrar, " Soundings in Bala Lake," *Geogr. Journ.*, vol. 118, 1952, pp.60–63.

[5] W. V. Lewis, " A Meltwater Hypothesis of Cirque Formation," *Geol. Mag.*, vol. 75, 1938, p.249–265.

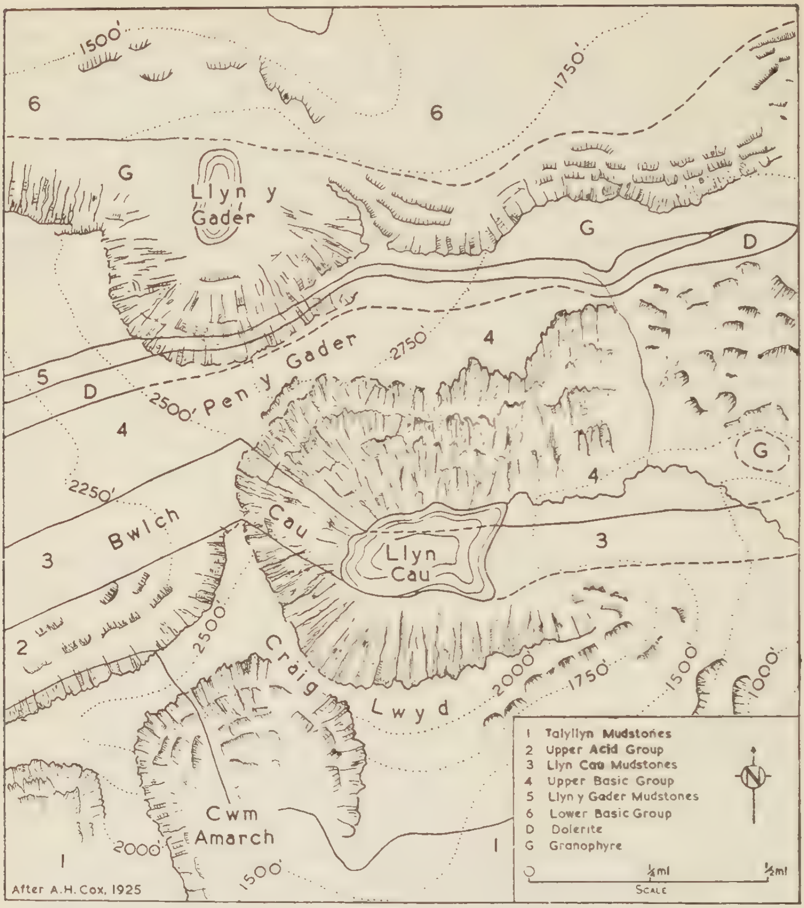

Fig. 1.—Llyn Cau in its topographic and geological setting.

paddles, levels, plane-tables and other equipment had to be conveyed by the party from Tal-y-llyn, an ascent of some 1,100 feet in $1\frac{1}{4}$ miles. A proper sounding line was used, made of phosphor-bronze woven wire to which was attached a heavy lead weight. Extension due to the addition of the weight was negligible. The line was marked at every foot by paint. The method was to row across the lake along lines joining points on the shore marked by ranging poles (Fig. 3). Three lines of soundings were made parallel to the longer axis of the lake, and three others transverse to that axis. The dinghy was kept to the survey line by signals from a member of the party onshore, who held ranging pole—dinghy—ranging pole in alignment. Certain other soundings were made at what appeared to be strategic points between the lines of soundings. In all 89 soundings were taken, each of which was fixed by alidade sightings from three plane tables suitably stationed on the lake shore (Fig. 3). Each line of soundings was designated by a colour, red, purple, etc., to facilitate subsequent fixing from the rays

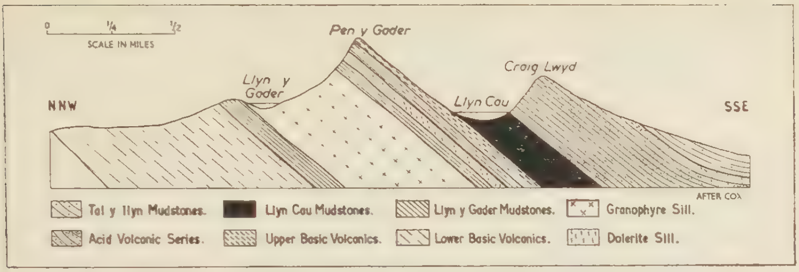

Fig. 2.—Geological section through Llyn Cau.

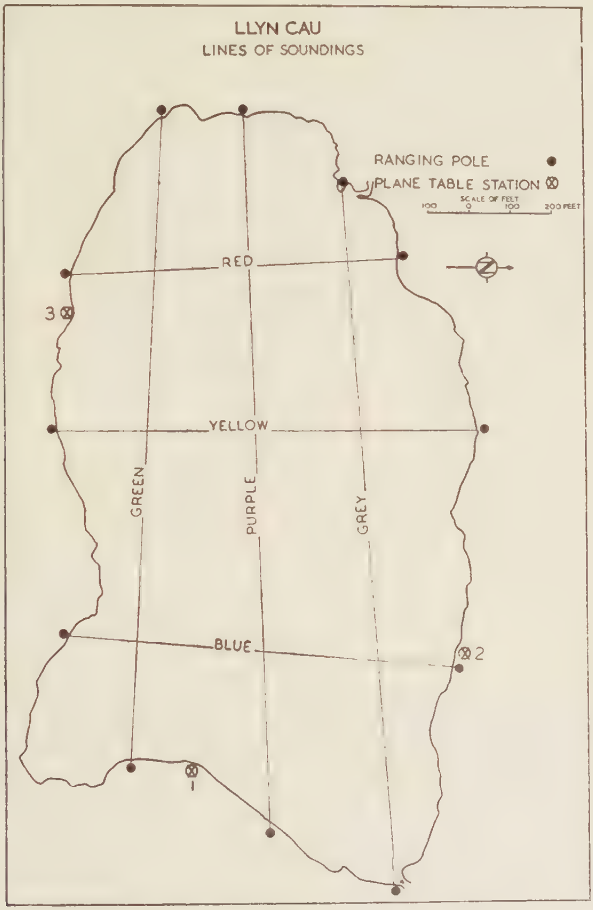

Fig. 3.

drawn on the three plane-table sheets. It was therefore a simple matter in the laboratory to correlate the soundings with their appropriate three-ray intersections. Owing to the size of the lake it was necessary each time a sounding was made to erect a short ranging pole in the dinghy and give a warning blast on a whistle. This was duly acknowledged by one, two, and three blasts on whistles from the

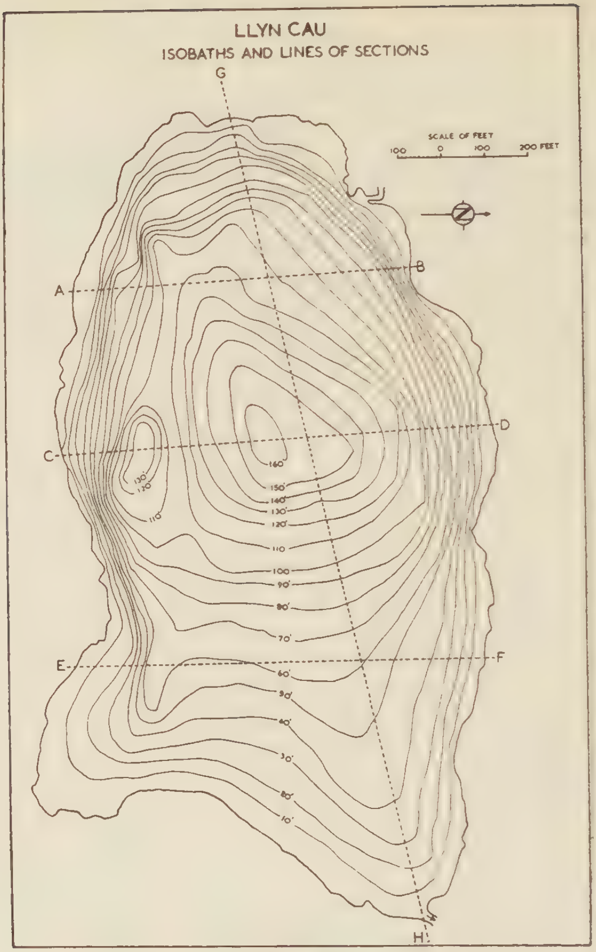

Fig. 4.

three plane-table stations in turn, a procedure which ensured that each and every sounding had been noted by each plane-table party before the dinghy moved to a new position. The distances between the plane-tables were measured three times in each direction by means of stadia lines on a Quickset Level and the bearing of each line was taken by a liquid prismatic compass. This procedure was necessary as the precipitous and rocky surround of the lake made laying out a normal base line impossible in the time available. The need to erect ranging poles on the lake shore as the terminators of the lines of soundings, and to make the shore and base-line measurements, meant that only two lines of soundings were completed on the first day. The other four lines of soundings, together with certain intermediate soundings were made on the second day.

While the soundings were being taken a second section of the party made an accurate compass traverse of the lake using a liquid prismatic

compass and a new chain. A third section of the party took lines of levels, firstly across the morainic material damming the lake and then, to a limited extent, up the scree which foots the headwall of the corrie.

Results

The altitude of the water surface, as determined by aneroid barometer readings was 1,552 feet above sea level. The lake has a greatest dimension (for convenience called the length) some 1,950 feet lying in an ENE–WSW direction with a maximum width of 1,080 feet at right angles to this axis. The mean breadth is 736 feet, being 36 per cent of the length. The area covered by the water of the lake is approximately 1,416,600 square feet, whilst the volume is 93,752,000 cubic feet. The average depth of the lake is 66·1 feet, being 40·5 per cent of the greatest depth of 163 feet which is located approximately in the centre of the lake. (Tables 1 and 2.)

The general underwater configuration is revealed in the contoured map of Llyn Cau (Fig. 4) and the sections (Fig. 5). The lake is surprisingly deep, in contrast to the opinion expressed by Lewis[6] in 1938 that it " does not seem to be of any great depth so that the headwall seems to flatten out quite suddenly, forming an L-shaped angle at the foot." The high, steep headwall, so typical of British cirques, is well developed at Llyn Cau. Within a horizontal distance of some 880 feet, it rises 1,100 feet above the lake surface (Fig. 5, Section VI) and it may be examined to within 40 feet of the lake. A smooth precipitous polished

TABLE 1

	Llyn Cau	Dulyn	Glaslyn
Elevation (feet above O.D.)	1,552	1,747	1,970
Area (sq. yds.)	157,400	166,520	105,600
Volume (cu. ft. × 10^6)	93·75	156·0	59·5
Maximum Depth (feet)	163	189	127
Mean Depth (feet)	66·1	104·0	62·6
Mean Depth as percentage of Maximum Depth	40·5	55·0	49
Maximum Dimension (feet)	1,950	1,680	1,605

TABLE II

Percentage of Superficial Area Corresponding to Different Depths of Water

Depth Interval (feet)	Llyn Cau	Dulyn	Glaslyn
0–20	20·6	10·2	15·7
20–40	14·0	7·6	16·9
40–60	15·0	7·9	15·2
60–80	13·5	9·6	15·8
80–100	11·2	11·9	17·0
100–120	12·7	11·0	14·5
120–140	7·3	8·4	4·9
140–160	5·7	8·9	——
160–180	——	14·5	——
180–200	——	10·0	——

[6] W. V. Lewis, *op. cit.* p.251–52.

surface comprises the lowest 100 feet visible above which the headwall surface is much riven and ascends at a slightly smaller angle. Large blocks, which obviously once formed part of the rock face now lie strewn along the lake side while others are to be seen partially dislodged from the headwall at varying angles. Thus there is ample evidence of wedging and shattering well below the 150-foot maximum depth of the bergschrund crevasse.[7] From sections drawn across the lake (Fig. 5, Sections I, II, III) it would appear that in general, slopes near the lake shore are steep, an almost vertical face descending into the lake at C. The cross sections also indicate that in places there is a ledge extending as far as the 10-foot isobath, probably marking the outer limit of the screes though in some cases a polished surface of low gradient was observed near the shore.

The longitudinal section (Fig. 5, Section D) shows the steep drop relatively near the headwall and the gentle rise to the morainic area to the east. This latter area is marshy and from it rise roches moutonnées and large boulders. Though this material undoubtedly helps to maintain the lake level, its removal would apparently cause only a slight drop in water level for bare rock forms the lake floor to within 20 feet of the eastern shore. At this point too, roches moutonnées are found within 50 feet of the water's edge.

[7] W. V. Lewis, "The function of Meltwater in Cirque Formation," *Geogr. Rev.*, vol. 39, 1949, p.118 states that the ice at the headwall of Cwm Cau must have been of the order of 625 feet thick when the glacier just reached the lip of the Cwm.

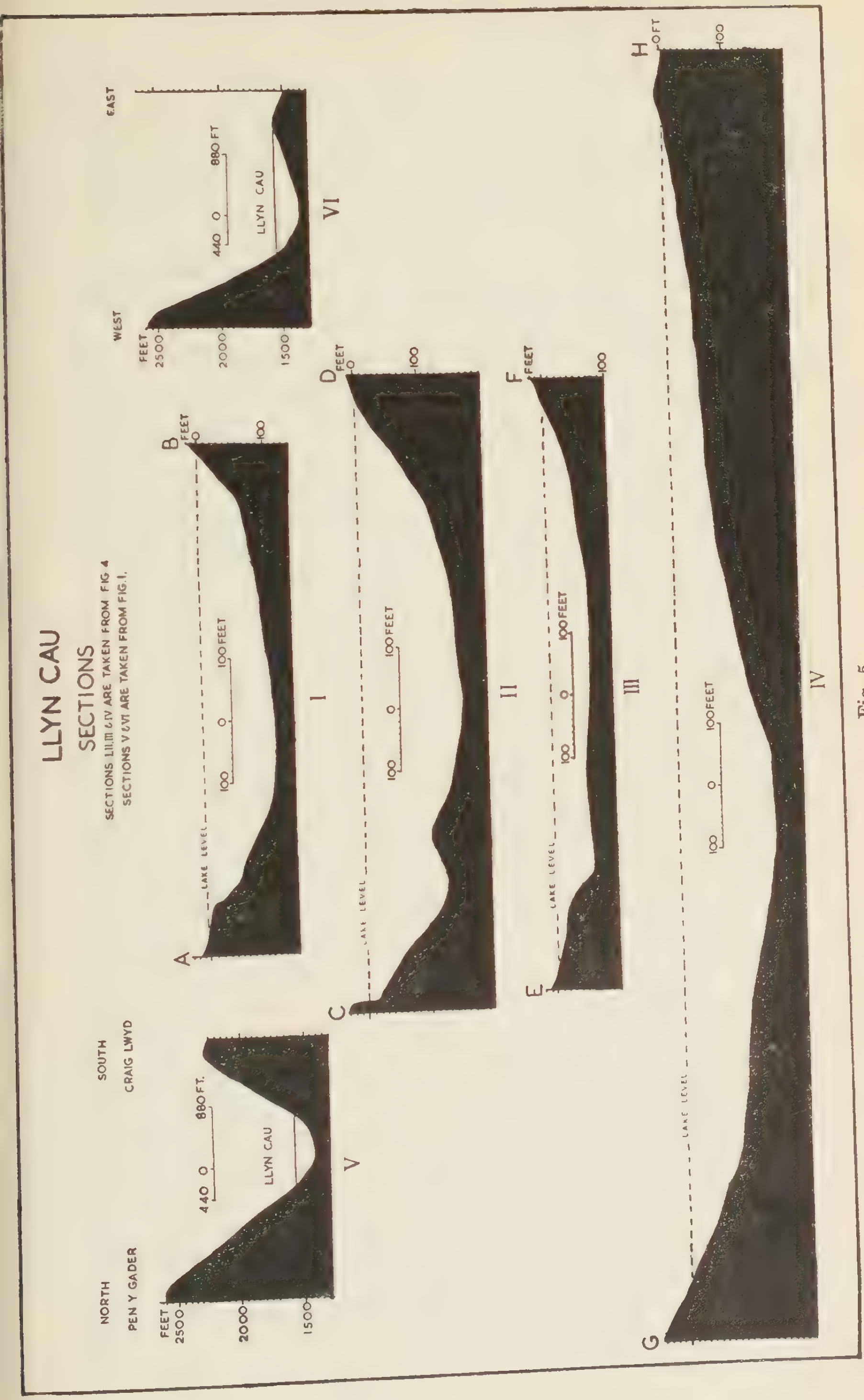
LLYN CAU
SECTIONS
SECTIONS I.II.III & IV ARE TAKEN FROM FIG 4
SECTIONS V & VI ARE TAKEN FROM FIG.1.
WEST
EAST
FEET 2500
2000
1500
440 0 880 FT
LLYN CAU
VI
NORTH
PEN Y GADER
SOUTH
CRAIG LWYD
440 0 880 FT.
V
A
B
FEET 0
LAKE LEVEL
100 0 100 FEET
I
C
D
II
E
F
III
G
H
0 FT
LAKE LEVEL
IV

Fig. 5.

THE STORM FLOODS OF 1st FEBRUARY, 1953

In the closing days of 1952 I wrote the words with which our 1953 volume opens: "A great storm merits the closest attention that can be paid to it. On the one hand it is the plain duty of scientists to study it in all its aspects—its origins, its development, its impact and its consequences—with the object of gaining knowledge that may be put to practical use in mitigating the disastrous effects of further storms when they occur. On the other hand scientists must also seize the opportunity which a great storm offers to advance their theoretical knowledge. A storm represents in many fields an opportunity to study nature working with an unaccustomed intensity and at a much accelerated tempo. It is as though the conditions of the great natural experiment which field scientists are privileged to observe had been temporarily altered, and it is important that they should discover and record faithfully as much as possible of what occurred during the brief period of altered conditions." Those words had particular reference to the great storm of rain that broke on Exmoor in the evening of 15th August, 1952, bringing calamity within a few hours to the coastal village of Lynmouth, and to the two articles on that storm which we were able to publish in our January issue.

Hardly was that issue in the hands of our readers, however, when Britain was stunned by the news of a storm disaster of entirely different origin, character and magnitude that had wrought death and destruction to our eastern seaboard to a degree not paralleled for centuries past, and had struck at our neighbours the Dutch even more grimly. It was felt by our Honorary Secretary that some attempt should be made in the pages of *Geography* to assist our readers to see the tragic events of 1st February, 1953, as a whole and in relation to their causes and effects. With characteristic energy she immediately embarked on a correspondence with possible contributors, and for her zeal and for the ready response which she evoked I must alike express my deep gratitude. Particular thanks are due to Professor Boerman for his contribution and to Professor Edwards for assistance in many forms.

What follows cannot pretend to be a balanced and comprehensive account of the storm-floods of February 1st. There is already an appreciable literature of the subject, as is indicated by the articles listed at the end of this paragraph, and it will surely grow as specialist analyses illuminate this or that aspect of an event whose proper understanding is of vital importance along both shores of the North Sea. Nor can the present survey claim uniformity. It is from several hands, and though the editorial pruning and re-writing to prevent overlap and secure unity have been more considerable than is altogether to the contributors' liking, their several contributions remain distinct in scope and intention. If all of them had been on the scale of the discussion of the Lincolnshire coastline by Mr. Barnes and Dr. Cuchlaine King our journal could not have contained them; but not to

have included one such detailed and thoughtful analysis of the formative and destructive processes as they operated on a particular stretch of coast would have been a failure to convey to our readers an essential aspect of this many-sided story. It is, in fact, our hope that the diversity of theme and treatment of our contributions may help to convey more effectively than could any reasonably brief account by a single hand, something of the diversity of both the scientific and the practical problems that are involved.—Editor.

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II. *Netherlands*

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R. Ver Loren van Themaat. "Watersnood, 1953." *ibid.*, p. 83.

J. W. G. Baron Sloet. "Watersnood 1953 door een ooggetuige." *ibid.*, p. 84.

J. W. G. Baron Sloet. "Dijkverhogingen systeem de Muralt." *De Ingenieur*, 27 Feb., 1953, p. 101.

J. J. Broeze. "De depressie voor de Watersnood en de mogelijke betekenis der regressie van het pool- en pakijs." *De Ingenieur*, 6 Mar., 1953, p. 111.

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I.—THE STORM SURGE OF 31st JANUARY—1st FEBRUARY, 1953

AND THE ASSOCIATED METEOROLOGICAL AND TIDAL CONDITIONS.

A. H. W. Robinson*

THE fundamental cause of the disastrous flooding which is discussed in the following pages was the raising of the water level of the whole southern part of the North Sea by what is known as a storm surge, superimposed on the normal tidal oscillation. The normal rise and fall of the tide at any place for which long-period tidal records are available is something which can be analysed mathematically in terms of the relative motions of earth, sun and moon and the harmonic characteristics of the nearby sea area, and so predicted for future dates with considerable accuracy. These "predicted tides" are published in the Admiralty Tide Tables[1] and records for selected British ports show that on 80–90% of occasions the observed tides rose or fell to within a foot of the predicted levels and within ten minutes of the predicted times. The discrepancies between predicted and observed values on the remaining occasions are mainly to be ascribed to meteorological factors. These may range from strong local offshore winds which may lower or retard high tide in a single estuary, to a great storm surge which raises sea-level over a considerable area and endures long enough to increase the height of successive high-waters. Such a heaping up of the waters of one region of the sea will normally be associated by a lowering elsewhere in regions of depletion; the sea surface thus becomes tilted and out of balance and the disturbance tends to move, rather like the tide itself, progressively from place to place, raising the water level everywhere as it passes. As it does so it may penetrate into inlets like those of the Thames and Scheldt and become magnified in height by being laterally constricted. And everywhere the effect of the surge on low-lying coastal areas will depend not only on its magnitude but also on the time of its culmination in relation to the tidal cycle and on the type of tide, neap or spring, which prevails during the period of its development.

The North Sea Basin, open to the ocean in the north and almost completely closed in the south save for the narrow Straits of Dover, is particularly susceptible to surges of meteorological origin. Between the disastrous surge of 1897 and that of February last, similar distur-

* Mr. Robinson is a lecturer in the Department of Geography, University College, Leicester. He wishes to acknowledge his indebtedness to the Hydrographer of the Navy for tidal information relating to the surge and for permission to base Fig. 3 upon a preliminary diagram prepared by the Tidal Branch, Hydrographic Department, Admiralty, and to the following who kindly supplied tidal observations: Blyth Harbour Commission; Dover Harbour Board; Essex River Board, Chelmsford; the Railway Executive, Newhaven; Ramsgate Borough Council; det Danske Meteorologiske Institut, Charlottenlund.

[1] *The Admiralty Tide Tables for the Year* 1953 (*European Waters*). Published by the Hydrographic Department, Admiralty.

bances were recorded around its shores in 1916, 1921, 1928, 1936, 1942, 1943 and 1949. Studies of these earlier surges by Doodson[2] and Corkan[3,4] have shown that many have the characteristics of a free progressive wave which, like the diurnal tide, travels around the coast of the North Sea in a counter-clockwise direction. Corkan also drew a distinction between a surge of external origin originated by a disturbance well to the north of Scotland and one of internal origin caused by local effects within the North Sea basin itself. For a surge of external origin, the rate of progression was shown to be identical with that of the diurnal tide.

The meteorological conditions which have accompanied these earlier surges have also been investigated and found to show marked similarities. In most cases a deep depression has developed well to the west of Scotland and subsequently moved quickly eastwards across the northern part of the North Sea and thence into the Baltic area. The movement of the depression responsible for the 1897 disturbance, however, differed in that its track across the North Sea was south-eastwards from the Orkneys to the German Bight.

The Meteorological Conditions Associated with the 1953 *Surge*

During the period 29th January–1st February, 1953, the meteorological conditions were remarkably similar to those which developed in 1897. The depression began to form southwest of Iceland on 29th January and moved north-eastwards. By 1800 hours on the following day it had deepened to 980 millibars and the centre lay south of the Faeroe Islands (Fig. 1). From there the direction of movement changed to southeast and by 0600 hours on 31st January the centre of the depression, which had now deepened to 968 millibars, lay well to the southeast of the Shetland Isles. During this initial stage, the winds over the North Sea, blowing from the southwest and south, gradually increased in strength reaching Force 6 in some exposed coastal districts. The tractive force exerted by these winds on the sea surface must have caused a flow of water from south to north out of the Flemish Bight and this may account, at least in part, for the abnormal lowering in the level of the predicted tide at Southend on the morning of Saturday, 31st January (Fig. 3).

From 0600 hours to 2400 hours on 31st January the movement of the depression to the southeast was maintained. Although a partial infilling had taken place, a strong ridge of high pressure developed over the Atlantic and built up to 1032 millibars, so that the steep pressure gradient over the North Sea in the rear of the depression was fully maintained. The winds had now veered to north-west and north and continued to blow with gale strength,

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[2] A. T. Doodson and J. S. Dines, "Report on the Thames Floods, 1928." *Met. Office Geophysical Memoirs*, vol. 5, No. 47, 1929.

[3] R. H. Corkan, 1948, "Storm Surges," *Dock and Harbour Authority*, Feb., 1948, pp. 3–19.

[4] R. H. Corkan, 1950, "The Levels in the North Sea associated with the Storm Disturbance of 8th January, 1949," *Phil. Trans. Royal Soc.*, Series A, vol. 242, pp. 493–525.

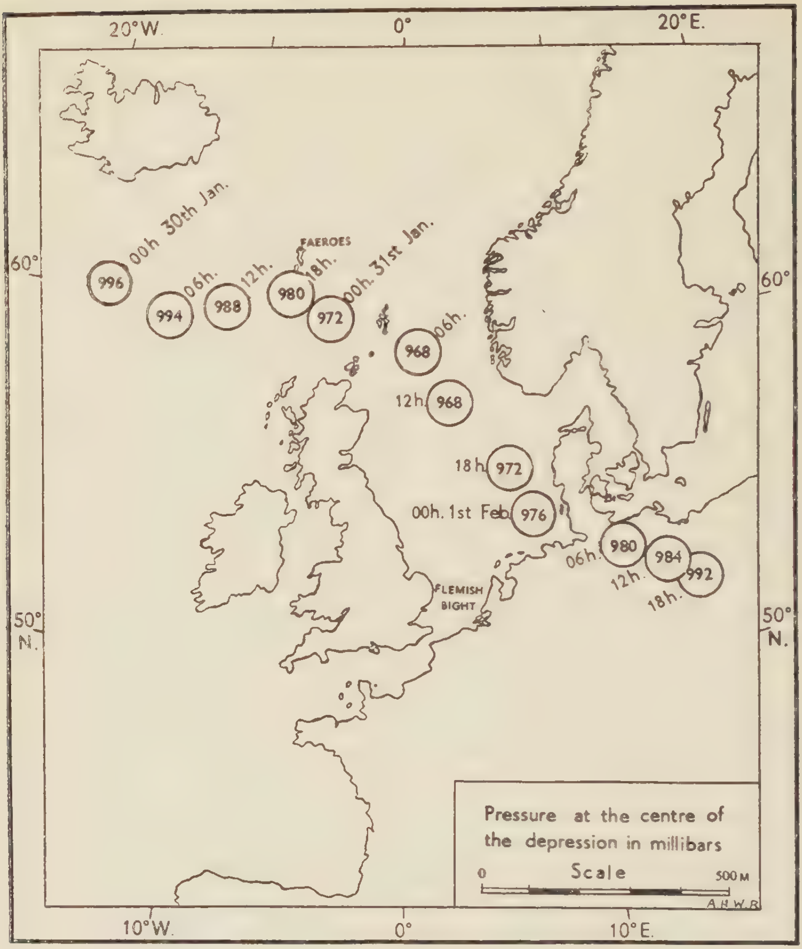

Fig. 1.—The track of the depression 30th January–1st February, 1953.

reaching Force 10 on the north-east coast of England and even greater force in north-east Scotland. Individual gusts with velocities of 113 m.p.h. were recorded at Kinross on the southern coast of the Moray Firth and 107 m.p.h. at Grimsetter in Orkney.[5] The veering of the winds would have the effect of reversing the flow of water previously expelled from the southern North Sea. Its return would tend to be down the east coast for it is deflected to the right by the earth's rotation.

In the final stage, as the depression moved eastwards across northern Germany and filled up, its place was taken by an anticyclone centred over Scotland. Although the winds continued to blow from

[5] Mr. C. K. M. Douglas has reproduced in the *Meteorological Magazine* for April, 1953, a photograph of the anemometer trace from Costa Hill, Orkney, which shows that between 0900 and 1000 hours the mean wind speed at the head of the 30 foot mast was 90 m.p.h. with gusts reaching 115–125 m.p.h.—Ed.

the north, they diminished in strength. By this time (1200 hours, February 2nd) the water disturbance had almost completely subsided.

Tidal Conditions Associated with the 1953 Surge

In order to determine the additive effect of the surge upon the normal tidal oscillation, the actual tidal height as recorded on a continuously registering tidal gauge can be compared with the predicted level as given in the Admiralty Tide Tables for 1953. The respective curves for Dover covering the period of the surge are given in Fig. 2. The difference in amplitude between the two sets of readings

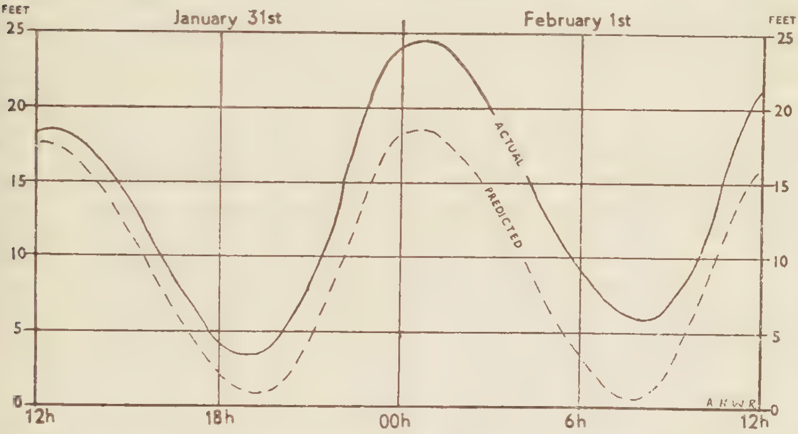

Fig. 2.—Predicted and actual tidal curves for Dover 31st January–1st February, 1953.

can then be measured and plotted as a graph of residual values—the meteorological element in the tide. Figure 3 was prepared in this way using data for various coastal stations in Scotland and England. Caution must be exercised in interpreting the residual values, for the predicted tidal curve may not be strictly accurate. This particularly applies to the mid-tide period when the tidal height is changing most rapidly and precise prediction is most difficult.

Although the residual curves are subject to this limitation, they will, nevertheless, give a reasonable indication of the vertical water movement and rate of progression of the surge. Reference to Fig. 3 shows that the maximum disturbance was felt at Aberdeen some two hours before the predicted time of high water on the morning of January 31st. From there it progressed down the east coast of Scotland and England, the rate being a little less than that of the diurnal tide. At Leith, the River Tees and Immingham, it arrived later than the predicted time of high water. The data for Yarmouth is based only on high and low water readings of the tide and so the time of the culmination of the surge in relation to high water cannot be ascertained. At Southend the maximum of the surge occurred earlier than the predicted time of high water whilst at Dover it occurred an hour after.

It will be apparent that even after making due allowance for the limitations of the data given in Fig. 3, the rates of progression of the surge and diurnal tide are not identical, and that the peak of the surge occurred with approximate simultaneity over a long stretch of coast-line. Moreover, the surge was maintained at a high level at many of the stations for a considerable time. At the mouth of the Tees, for example, the residual value was over 6 feet for about five hours whilst at Dover the sea surface was 6 feet above its predicted level for 6½ hours. These facts suggest that the greater part of the surge was internal (i.e. originating in the North Sea itself), being accompanied by abnormal sea surface gradients established directly by winds blowing with gale force.

The magnitude of the vertical rise of the sea surface above its predicted level varied considerably along the east coast (Table I). In general it was greatest in the south which is to be expected from the funnel-like shape of the North Sea, especially its southern basin—the Flemish Bight. The Straits of Dover to some extent acted as a barrier to the progression of the surge into the English Channel but even at Newhaven the tide rose 3·2 feet above its predicted high water level, when, with northerly winds blowing from land to sea, it is normal for the tide to cut.

TABLE I

Station	Predicted time of High Water	Predicted H.W. height above Mean Sea Level	Actual observed height at time of predicted H.W.	Greatest observed height	Surge at H.W.	Remarks
	Jan 31					
Aberdeen 57°.9′N; 2°.5′W	14·10 h.	6·3 ft.	8·9 ft.	8·9 ft.	2·6 ft.	Gauge defective from 16.00 hrs. Jan. 31.
Leith 55°.9′N; 3°.12′W	15·20 h.	7·7 ft.	9·4 ft.	10·2 ft.	1·7 ft.	
Tees 54°.37′N; 1°.12′W	16·45 h.	7·8 ft.	13·1 ft.	13·6 ft.	5·3 ft.	
Immingham 53°.37′N; 0°.12′W	18·55 h.	10·8 ft.	16·3 ft.	16·5 ft.	5·5 ft.	Gauge partially defective.
Yarmouth 52°.36′N; 1°.43′E	22·00 h.	2·9 ft.	10·8 ft.	10·8 ft.	7·9 ft.	Heights based on High and Low Water only.
	Feb. 1					
Harwich 51°.56′N; 1°.17′E	00·50 h.	5·5 ft.	12·2 ft.	13·1 ft.	6·7 ft.	Gauge destroyed. Data based on flood levels.
Southend 51°.33′N; 0°.44′E	01·40 h.	8·5 ft.	14·7 ft.	15·1 ft.	6·2 ft.	
Ramsgate 51°.20′N; 1°.25′E	00·43 h.	8·7 ft.	14·3 ft.	14·4 ft.	5·6 ft.	
Dover 51°.7′N; 1°.19′E	00·20 h.	10·0 ft.	16·2 ft.	16·3 ft.	6·2 ft.	Tide was highest ever registered at the port.
Newhaven 50°.48′N; 0°.4′E	00·39 h.	9·6 ft.	12·8 ft.	12·8 ft.	3·2 ft.	

Along the Dutch coast the magnitude of the surge was even greater, if the heights given in Table II are reliable.[6] On the open coast the vertical rise was 9 feet on an average whilst in the narrowing channels of the inner Scheldt estuary, it exceeded 10 feet. Part of this rise must have been due to local sea surface gradients established by onshore north-westerly winds.

[6] Even greater values, exceeding 13 feet at some places, are mentioned by H. A. Q. van Ufford in a footnote in his article in *Weather*, cited on p. 133.

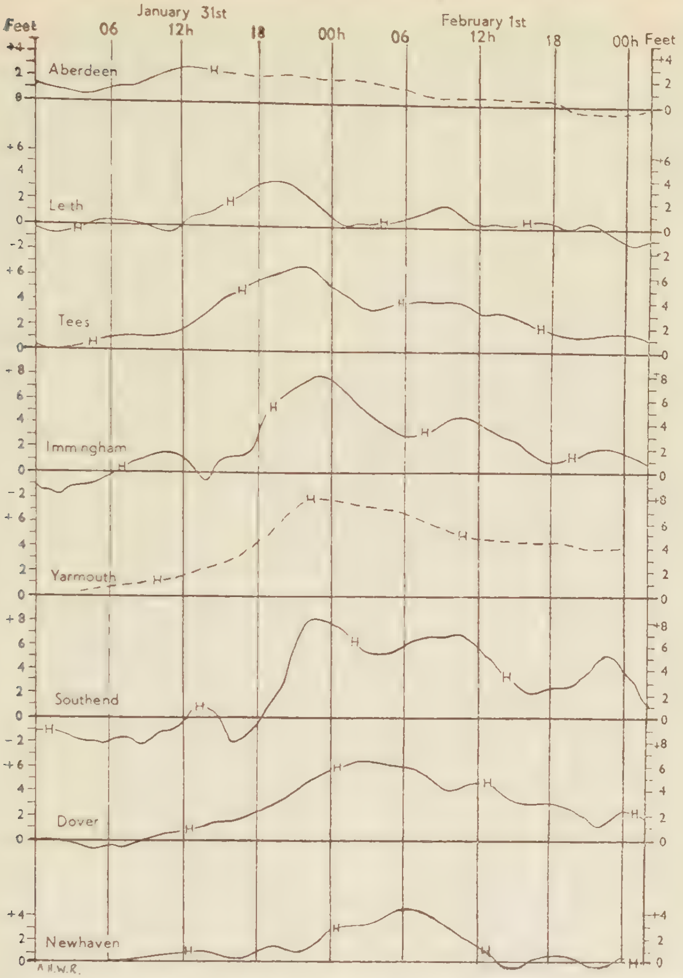

Fig. 3.—Graphs of residual values (observed minus predicted tide) for selected ports 31st January–1st February, 1953. H signifies time of high water.

Most of the curves of residual values show that the surge was characterised by a number of minor oscillations superimposed on a major oscillation with a period of about 36 hours, the amplitude of which became successively damped. The latter oscillation results from the wind over the southern North Sea blowing from the south-west and south during the initial stage of the disturbance and later veering to blow in the opposite direction. The impulse imparted to the sea surface by these gale force winds is sufficient to set it in motion and cause it to oscillate in its own natural period. Frictional forces tend to resist the oscillatory motion leading to a decreasing amplitude of its successive peaks. This free damped major oscillation, extending over a period of several days, does not appear in the residual curves ; the minor oscillations, however, are well shown in many of the curves

TABLE II

Station	Latitude	Longitude	Predicted time of High Water	Surge at High Water
Flushing	51°.27′N	3°.35′E	Feb. 1 02·24 h.	8·5 ft.
Willemstad	51°.40′N	4°.26′E	05·05 h.	10·3 ft.
Hook of Holland..	52°N	4°.9′E	03·30 h.	10·0 ft.
Rotterdam	51°.55′N	4°.30′E	05·07 h.	9·2 ft.
Scheveningen ..	52°.6′N	4°.16′E	03·49 h.	9·7 ft.
Harlingen	53°.10′N	5°.26′E	10·30 h.	9·9 ft.
Delfzil	53°.19′N	6°.55′E	12·43 h.	7·3 ft.

of the east coast stations for which complete and reliable tidal records are available.

At the time of the development of the disturbance on January 31st, the North Sea coasts were experiencing spring tides. The spring tide period, which repeats itself approximately every 15 days, is marked by tides having a greater range than those of the intervening neap period. Thus at Dover a spring tide, on an average, rises 4 feet higher and drops 4 feet lower than the corresponding neap tide.

It is apparent from the foregoing that the severity of the 1953 surge was due primarily to a combination of extreme meteorological and near extreme tidal conditions. The fact that disturbance took place during the spring tide period meant that only a further small vertical rise of sea level was needed for sea defence embankments to be overtopped in low lying areas. The additional rise was provided by the surge which along many stretches of coast reached its maximum amplitude near the time of high water. In addition, the gale force winds blowing with constant strength and direction for a long period meant that along exposed coasts sea defences were damaged and broken by large storm waves breaking higher up the beach than is normal. The breaches created were later exploited by the inflated tide with disastrous results.

In severity the 1953 surge stands comparison with any experienced in the past. It is important to realise, however, that had it coincided with the equinoctial spring tides, the disaster might have reached even greater proportions. For Dover the predicted astronomical tide is some two feet higher in mid-March than at the beginning of February, whilst at Immingham the corresponding difference is about 4½ feet. This fact must be taken into account when consideration is given to the problem of strengthening and raising the height of the sea defence embankments to prevent a recurrence of the flooding.

In his concluding paragraphs, Mr. Robinson makes mention of the fact that the storm surge, whose nature and origin he discusses, was associated with large and damaging storm waves. This point deserves amplification for there is some reason to think that the waves developed on January 31st were unusually large, and perhaps as large as any that can be generated in the North Sea. There are no measurements of wave height available to substantiate this belief but the conditions were certainly such as to give rise to very powerful storm waves, and the damage inflicted at some places conveys a strong impression that this was so. On January 31st the weather map showed throughout the day parallel isobars running from NNW to SSE over the western North Sea with an unusually strong gradient from west to east. The gradient, according to Mr. C. K. M. Douglas,

was such as to give rise to a geostrophic wind of 175 m.p.h. at noon over a belt more than 100 miles wide, and at 6 p.m. there was " a long belt with a geostrophic wind averaging about 140 m.p.h. over the whole of the western and central parts of the North Sea." No wonder he goes on to state that " this was much higher than anything previously recorded in this century." These winds were blowing for a long period so that the effective length of fetch of waves reaching exposed portions of the coast in Lincolnshire and Norfolk may have been 400 miles or more, and in these circumstances waves of more than 20 feet from crest to trough could be expected.

Mr. W. W. Williams has recorded (in the article cited on p. 133) that on the morning of February 1st on the Suffolk coast south of Lowestoft the waves were " of a size and violence that he had never previously observed in the North Sea " and he allows me to add that they were receding so far in the trough that he could see more of the beach than he had ever seen before. In the interval since the previous afternoon a 40-foot high cliff of sand had had so much material carried away that the face had been driven back 40 feet : where the cliff was only 6 feet high the face had been pushed back 90 feet. Such wholesale removal of material shows clearly how the destructive effect of the powerful waves moving onshore was enhanced by a strong hydraulic bottom current moving in the opposite direction and carrying away beach material that would normally help to protect the coast. Beaches were combed down or stripped to bed-rock at many exposed points, and large waves were then able to reach the shore unbroken. There they broke on and over the shore defences and the swash moving inland and downhill was able to effect powerful erosive action which weakened sea-walls and led to dune breaches. Where the waves encountered fixed structures these were severely battered, even though standing above the level of the top of the tide as the bungalows in the Heacham area and the overturned and crumpled beach huts at Mablethorpe bear eloquent witness.

The meteorological conditions that produced the storm surge were also those that generated exceptional storm waves and the effects were additive. By raising sea level the storm surge made possible severe wave attack high up or even on the landward side of the coastal defences : in this way breaches in those defences were multiplied and through them the waters could pass inland, not merely at high tide, as was the case in sheltered areas where the defences were merely overtopped, but for very substantial periods for many successive high waters.—

EDITOR.

II.—THE LINCOLNSHIRE COASTLINE AND THE 1953 STORM FLOOD

F. A. BARNES and CUCHLAINE A. M. KING*

APPROXIMATELY 158,000 acres of land were flooded by salt water in Britain on the night of January 31st, and of these more than 20,000 were in Lincolnshire, where the damage to the coastline was exceptionally severe. But a proper appraisal of the events of that night is not possible merely in the light of the meteorological and tidal conditions obtaining at the time. The Lincolnshire floods of 1953 to be truly understood must be seen in a long perspective, as an incident in the continuing evolution of the coastline throughout post-glacial and historical times.

Lincolnshire east of the Wolds is underlain by a foundation of Chalk in the form of an ancient wave-cut platform which is everywhere

* Mr. Barnes and Dr. King are members of the staff of the Department of Geography in the University of Nottingham and have for some time been engaged in joint research into the morphological and ecological problems of the Lincolnshire coast and particularly of the area of Gibraltar Point.

below present sea-level. Resting on this platform, and banked up against the former cliff-line at its inland margin is a cover of boulder clay, generally some 80 feet thick, whose hummocky upper surface, ranging in altitude between 15 and 100 feet above the sea forms the so-called Middle Marsh. Eastwards of the Middle Marsh this hummocky boulder clay declines further and passes under the post-glacial clays and silts that constitute the Outmarsh, and so well beyond the present coastline. Some of the higher of its irregularities protrude through the levels of the Outmarsh to form " islands " a little above their surroundings. East of Alford in the Huttoft-Chapel St. Leonards area, where they represent the partly buried moraines of a retreat stage of the last glaciation, such hummocks are sufficiently numerous to be regarded as an eastward salient of slightly higher ground transitional between the Middle Marsh and Outmarsh. Because they resist erosion better than the more recent deposits such hummocks may be responsible for the existence and location of some of the present coastal headlands, including Chapel Point and Ingoldmells Point.

An explanation of the post-glacial evolution of the Lincolnshire coast by Prof. H. H. Swinnerton is pertinent to this discussion[1]. After the retreat of the ice sea level stood much lower than at present, and the sea lay far to the north and east of the coast of to-day. Forests became established on the boulder clay surface. A substantial and prolonged rise of sea level began seriously to affect the present coastal districts after the Neolithic period, but before the sea covered the Outmarsh area, the deteriorating drainage and a moister climate caused the formation of peat, which is now often visible at about low spring tide level enclosing the stumps of the former forest. As the rise of sea level continued the Outmarsh area became covered with tidal saltmarsh clay, the deposition of which could only occur under protection from the waves of the open sea. Swinnerton suggests that protection was provided by a morainic zone along the general line of the Protector Outfalls and Inner Dowsing, some 10 miles from the present coast (see Fig. 2).

When the rise of sea level slowed about the end of the Bronze Age period, brackish and freshwater marsh clay and peat were laid down above the saltmarsh clays, but by Roman times sea level was rising again, and the upper tidal silts were subsequently deposited above the Iron Age peats. It is suggested that the offshore barrier was finally breached during the stormy period of the thirteenth century, due partly to wave action, and partly to the rise in sea level. From the abundant debris available about this time a beach and associated dune line would be formed by wave and wind action much nearer to the present coast than was the earlier offshore barrier. From this period onwards the Outmarsh was not regularly inundated, but the new shape of the Lincolnshire coastline was unadjusted to the marine forces acting upon it, and the process of adjustment, continually

[1] H. H. Swinnerton: *Quart. Journ. Geol. Soc.*, vol. lxxxvii, 1931, p. 360. *Trans. Lincs. Naturalists Union*, 1936, p. 91.

resisted by man, is still proceeding. Since the thirteenth century the occupation of the Outmarsh has involved a continual struggle against recurrent breaching of the dune belt, widespread flooding of the Outmarsh, and loss of land to the sea. Such events are not abnormalities in the geomorphological sense ; they are characteristic of the normal course of marine transgression on a low dune coast.

On account of the convex curve presented to the sea by the coast of Lincolnshire, the section between Saltfleet and Skegness has all been subject to erosion over the past centuries. The danger is rendered more serious than ever to-day because sea level is still rising at a rate which has been estimated to be of the order of 1 mm. per year[2]. Along this coast much of the land behind the dunes and sea walls lies well below the level of the higher tides. For example, mean high spring tides reach 10·9 feet O.D.[3] at Skegness, and 11·4 feet O.D. at Grimsby, while spot heights on the Outmarsh vary between 7 and 10 feet along the roads, and the fields are often lower. The effectiveness of the coastal barrier is therefore vital to the continued use and occupation of this valuable low-lying area. The developing salt marshes south of Skegness, which are regularly flooded by the higher spring tides, range up to 11 or 12 feet O.D. They are thus appreciably higher than the Outmarsh further north. Assuming that the tidal range has not changed appreciably, these figures suggest an effective rise of sea level of about 3 feet since the Outmarsh as a whole ceased to be regularly flooded through protection by dunes, and became " permanent " land. Such a rise of sea level over 750 years (since the early thirteenth century) would represent a rate of the same order as that suggested by Ahlmann as operating in recent decades.

Effective sea defences thus require to be continually raised in height if the sea is to be frustrated in its work of straightening the coastline. The supply of sand needed to maintain the natural defences of dunes and beaches over a long section of the coast may have become increasingly inadequate with increasing submergence of the foreshore. If land is not continually to be sacrificed the defences must be made increasingly stronger as well as higher, in order to meet the more powerful wave attack permitted by deepening water over the beach. Breaches must produce more and more serious results in the low Outmarsh and the floods caused by the recent storm were potentially more damaging than any previously caused by comparable tidal and wave conditions. This long-term factor must be set against any optimism based on the low statistical frequency of such combinations of storm and tide.

Historical Evidence of Repeated Inundations and Erosion

Erosion on a low dune coast may excite little outside attention because it proceeds insidiously on the foreshore. There are no falls of cliff to advertise its progress, and the loss of land is discontinuous.

[2] H. W. Ahlmann, " The present climatic fluctuation," *Geog. Journ.*, vol. cxii, p. 165.
[3] The Liverpool datum is used throughout.

A. E. B. Owen has recently marshalled a body of historical evidence[4] which reveals that the recent disaster is but the latest example in a long series of breaches and floods, which have together effected the retreat of the coast. A selection of this evidence is tabulated here.

Year	*Place*	*Damage, loss, etc.*
1272	Ingoldmells	Seawalling a customary service.
1287	Mablethorpe	St. Peter's church "rent asunder by the waves." (Broken seabanks and floods in S. Lincolnshire).
1335	Mablethorpe	Severe flood in August, with breaches at Mablethorpe and along the nearby coast.
1365	Ingoldmells	Seabank in disrepair.
1404	Ingoldmells	Cattysacre devastated by the sea.
1421	Ingoldmells	Flooding (St. Elizabeth's flood drowned 10,000 people in the Netherlands.)
1422	Ingoldmells	Flooding.
1430	Widespread	Widespread flooding and breaching suggested by the powers granted urgently to Commission of Sewers for Lindsey. Floods at Ingoldmells. Mablethorpe sea wall under repair. Land at Skegness repeatedly overflowed.
		In 1443 Lord of Mablethorpe manor exempted from offices and services in consideration of loss of land and repairs to defences.
1485		Diminished rents of Ingoldmells manor, which included part of Skegness *per fluxum maris*.
1503		Survey classified :
	Skegness and Theddlethorpe (possibly Ingoldmells)	In very great danger of the sea.
	Mablethorpe	In great danger of the sea.
	Saltfleet and Croft	In danger of the sea.
1517	Skegness and Winthorpe	Land permanently lost despite repairs to defences.
1526	Skegness	Church and much of parish submerged, and remained so. Leland (c. 1540) described an entirely new settlement.
1529	Mablethorpe	Lands "overflowed by the sea."
1540–1560		Considerable damage though actual dates uncertain.
	Mablethorpe	St. Peter's church and most of its parish probably lost in middle or late 1540's.
	Skegness	Rectory destroyed in severe flood c. 1550. Much land lost. New banks being built in 1560.
1571	Widespread	Widespread severe floods. Village of Chapel St. Leonards destroyed except for three houses. One thousand one hundred sheep lost by one man there.
1616	Skegness	140 acres finally lost.
1626	Ingoldmells	Reference to ground lost on Winthorpe side of parish. Manor sold at reduced value.
1631	Skegness	Hobthirst Hill, on King's Low Marsh, destroyed by the sea.
	Sutton	Bank in ruins : much swept away : new bank built behind.
1637	Sutton	Petition stressed longstanding danger of position. Church, houses and much land lost to sea 70 or 80 years earlier, i.e. probably in 1571 floods : still under sea.
	Ingoldmells	Bank linking Bell Bank, Chapel with Ingoldmells Bank, already badly damaged, carried away completely by "a sudden breach of the sea." Land behind flooded : new bank built behind, and land in front abandoned.

[4] A. E. B. Owen. "Coastal erosion in E. Lincs." *Lincolnshire Historian*, No. 9 (1952), p. 330.

Year	*Place*	*Damage, loss, etc.*
1639	Skegness	Dunes "partly destroyed and broken through."
1645	Mablethorpe etc.	Very severe inundation in north, including Mablethorpe, Withern, Strubby and Maltby parishes. New bank at Mablethorpe North End came too late.
1665	Ingoldmells and Addlethorpe	Now much reduced in area and population. Much good ground lately lost, and more in imminent danger, due to "the violent breaches boarding upon these coasts."
1735	Ingoldmells and Addlethorpe	February 16th: a strong northwest wind and spring tide (probably a surge very similar to that of 1953). Over a mile of Ingoldmells Bank overflowed. Most land in Ingoldmells and Addlethorpe in front of Dydick Bank flooded for three weeks.
	Anderby	In 1778 an old man at Anderby remembered a flood reaching the parsonage (2 miles inland), probably in 1735.
1777	Sutton	Great breach at Sutton shown on Armstrong's map of 1778.
1789	Sutton	The sea "makes alarming inroads." Eight acres recently lost.
1837	Winthorpe	Flood mark on Winthorpe church 8 ft. 9 in. above ground.
1883	Sutton and Trusthorpe	Severely hit by very high tide: expensive defence works needed.
1947	Sandilands	Concrete steps at Sandilands badly broken. Large breaches in dunes along Sutton Golf Course.
1949	Chapel	Severe damage to dunes north of Chapel.

This summary confirms the view that during the past six centuries the coastline has been forced continually landwards, new protecting banks being repeatedly built and the land in front abandoned. On many of the occasions mentioned it may be assumed that areas other than those named also suffered. Between Mablethorpe and Skegness five medieval parish churches have been lost to the sea. The village of Mablethorpe St. Peters, probably north-east of the present St. Mary's church, has disappeared; the number of communicants in St. Peter's parish declined from 67 in 1603 to four in 1722. Trusthorpe, Sutton, Chapel St. Leonards and Skegness have been forced to change their sites. Owen estimates that between Mablethorpe and Skegness the sea has advanced between a quarter and half a mile over the last 400 years, but the incidence of erosion must necessarily have varied as the shape of the coastline has changed. The portion of the present coast subject to erosion is generally similar in extent to the section long affected, but no longer includes that southwards from northern Skegness where much land seems to have disappeared since the fifteenth century, including the North Common, and possibly the original ness of Skegness. Skegness was still subject to inundation in the mid-seventeenth century but for the last 150 years at least accretion and reclamation has been proceeding there. The outer dune belt between Skegness and Gibraltar Point and the mature marsh behind it were formed between 1824 and 1870. Old maps (O.S. 1st Edn. 1824, and Greenwood, 1831) indicate perceptible erosion round Ingoldmells Point since 1800, and there erosion continues[5]. Similarly the section

[5] 500 yards of sandhills at Ingoldmells were destroyed in 1877. See A. J. Jukes-Browne: *Geol. of part of E. Lincs.* (Mem. Geol. Surv., 1887).

north of central Mablethorpe appears no longer to be dangerous; under present conditions accretion and protection are possibly tending to extend very slowly southwards at Mablethorpe, though hampered by coastal works. There are few historical records of damage at Huttoft and Anderby, which suggests that erosion has not been serious there, and the survival of the Roman Bank in that area supports this conclusion. The Anderby vicinity is still somewhat favoured in this respect by comparison with the coast to the north and south.

Inland banks between Skegness and Saltfleet are not to be considered as parts of reclamation schemes enclosing ground newly won from the sea. Their object has been to protect land already used, either from the sea side, or from lateral flooding from adjacent drainage basins. The so-called Roman Bank, a conspicuous feature approximately parallel to the coast, appears to have been built in sections at various dates as a second line of defence. It is probably mainly late medieval or later—a response to the increasing vulnerability of the natural defences to wave attack as this has intensified with the rise of sea level. Newer banks seaward of the Roman Bank south of Skegness and Croft, however, are associated with relatively recent reclamations of newly-formed marsh in the sheltered areas of silt accretion within the Wash. The varying position of the Roman Bank relative to the present coastline affords a rough indication of the areas of erosion and accretion since late medieval times. It suggests a wide area of accretion south of Skegness, but substantial erosion where the line of the bank is cut by the coast between Mablethorpe and Sandilands, and between Chapel St. Leonards and Ingoldmells. (See Fig. 1.)

The Floods of January 31st–February 1st, 1953

The amount by which the evening tide of January 31st exceeded the predicted height appears to have increased progressively southwards from 5·5 feet at Immingham to 7·8 feet at Gibraltar Point, though the absolute level of the water, 17·6 feet O.D., was the same at both places. The 20,000 to 21,000 acres of flooded land thus ranged along most of the littoral belt of Lindsey. In addition to limited areas in the middle Humber and the Wash, the flooded lands of Lindsey fall into three geographical groups. (See Fig. 1.)

(*a*) *North of Grimsby*

In this sheltered area most of the Outmarsh, which is relatively narrow, was flooded due to overtopping. Many sections of sea bank were lowered by 1½ to 2 feet through erosion by the overtopping sea water, but there were no major breaches.

(*b*) *Grimsby to Saltfleet*

Between Grimsby and Northcoates Point floods were not extensive. At Grimsby and Cleethorpes the Middle Marsh reaches the coast, and the possibilities of flooding are limited. South of Cleethorpes the sea bank was high enough to restrict flooding to the area seaward of it, apart from a minor penetration along Buck Beck. The Outmarsh was in less danger than that further south because it is generally as

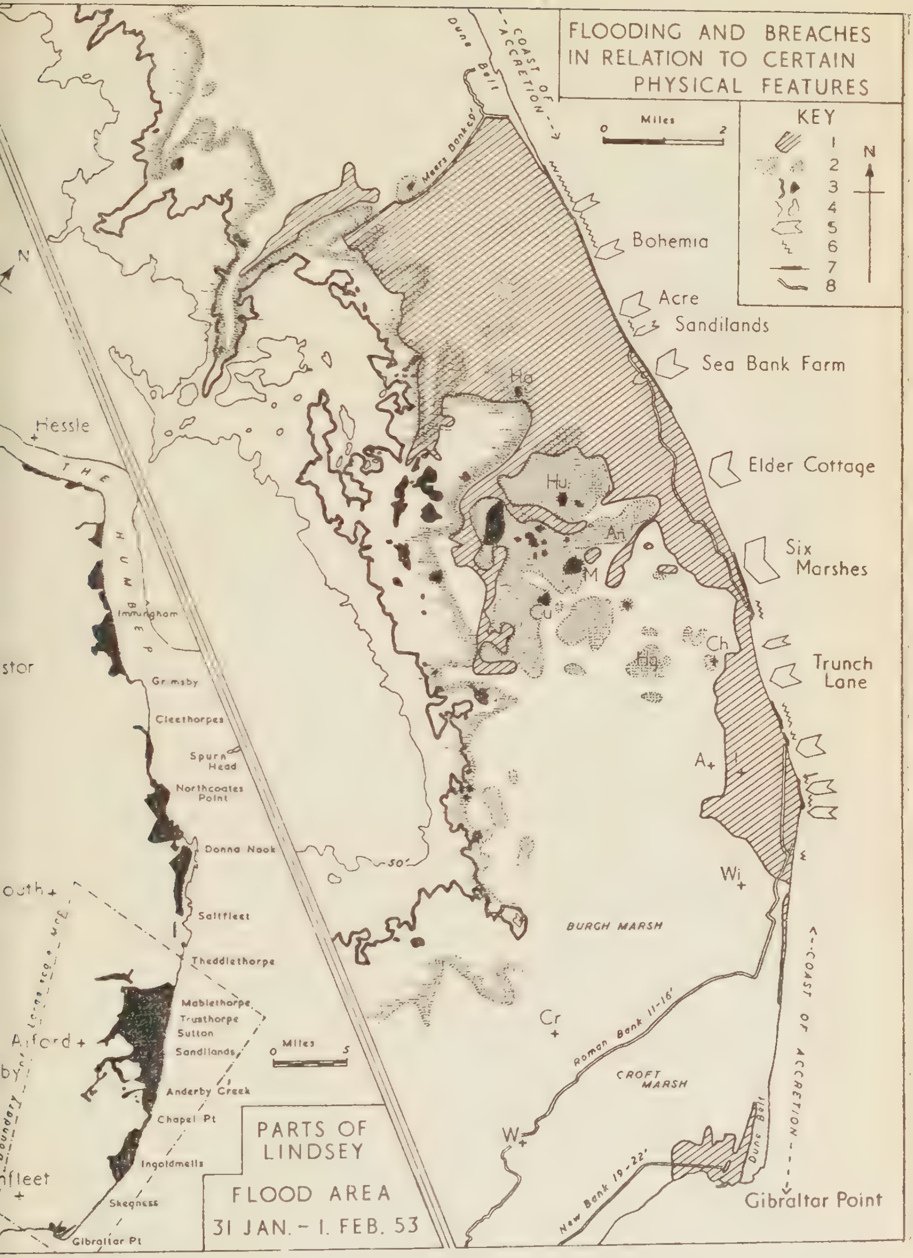

Fig. 1. Key: 1. Flooded areas. 2. Boundary of main boulder clay outcrop and isolated hummocks. 3. 25 ft. contour and enclosed areas above 25 ft. 4. 50 ft. contour and enclosed areas above 50 ft. 5. Major breaches. 6. Badly damaged coastal defences. 7. Sea walls. 8. "Roman" and other banks. A—Addlethorpe; An—Anderby; Ch—Chapel St. Leonards; Cr—Croft; Cu—Cumberworth; Ha—Hannah; Hg—Hogsthorpe; Hu—Huttoft; I—Ingoldmells; M—Mumby; W—Wainfleet; Wi—Winthorpe.

high as 10 to 11 feet O.D. South of Northcoates Point the flood was more extensive, but was limited inland by the slightly higher loamy area upon which stand the villages of Northcoates, Marsh Chapel and Wragholme. Between Donna Nook and Saltfleet the flooded area narrowed southwards, contained on the west side by a sandy zone upon which North Somercotes is sited, probably an old dune system some 3 feet above the surrounding marsh[6]. In this section wave action was not severe due to both the partial shelter from the north, and the protection afforded by a wide beach.

(c) *Saltfleet to Skegness*

From Saltfleet to Mablethorpe the substantial dune belt was not breached, although the exposure of the coast increases. A small area of marsh along the lower Great Eau near Rimac House was flooded, and water penetrating along the embanked channel of the Great Eau covered a low strip of fenland, which was still unreclaimed in the late eighteenth century. On the clay Marsh, however, Meers Bank, only about 9 feet O.D., was high enough to contain flood water penetrating from the breaches to the south. South of Meers Bank, by contrast, practically the whole Outmarsh as far south as Chapel St. Leonards was under water, and some low areas of boulder clay were also covered. The Outmarsh here is particularly low, and the abnormality of tide height on January 31st increased southwards, but the decisive factor was the magnitude of the coastal breaches between Mablethorpe and Sea Bank Farm (see Fig. 1 and Plate 1). These permitted free access by the sea for a relatively long period on account of the low levels to which they were cut, and by their substantial widths allowed the ingress of huge volumes of sea water. Even in this section the level of the flood well inland did not much exceed 9 feet O.D., which is many feet lower than the maximum water level at the coast. This discrepancy reflects the substantial time taken for water rushing through the breaches to fill the dykes and spread over the country, and the fact that this process was checked by the ebb of the tide.

Between Sandilands and Chapel Point the Roman Bank, though overtopped and partially breached in places, for example near Sea Bank Farm, acted as an effective brake on the extending flood, and although the area seaward of the bank was deeply flooded the water was much shallower on the landward side (Plate II). This protection was absent north of Sandilands Golf Course, and the sea flowed inland unimpeded.

Towards Chapel Point the flooded zone narrowed, due to the increasing measure of protection afforded by the Roman Bank, and the extent of inliers of boulder clay. The Outmarsh clays in this area are also very slightly higher. The several breaches along the coast south of Chapel Point were not at such a low level as those north of Sea Bank Farm. The Ingoldmells-Chapel road was high enough to contain the flood, but elsewhere it penetrated along dykes and in the absence of a protective bank its height was limited only by the height

[6] A. J. Jukes-Browne, 1887, *op. cit.*

of the breaches and the period of high water. South of Butlin's Camp local flooding was due to overtopping into dune slacks.

While flood water extended at one stage without interruption from northern Skegness to Mablethorpe North End, its penetration inland varied widely. There were some deep salients into the Middle Marsh along drainage channels, for example into Farlesworth Fen. The whole flooded area has been subject to periodic inundation during the past six centuries, but the destruction of life and property in 1953 was probably unprecedented because of the recent crowding of settlements and population into the most dangerous zone immediately behind and upon the dunes, and seaward of the Roman Bank. This is a geographical process closely comparable with the spread of cities like Nottingham into the flood plains of rivers.

Structural damage was most serious along the sea front where houses and other substantial buildings and promenades were wholly or partly destroyed along with the defences upon which they were built. There was also serious damage immediately behind the defences, where water swept through complete and partial breaches. Caravan sites are numerous along this coast on low, level ground behind the dunes, and especially in the deeply flooded area between the dunes and the Roman Bank; they suffered very severely through the combined action of deep flood, waves and wind. Deep flooding by salt water caused damage to all houses and their furnishings in the flooded coastal settlements of Mablethorpe and Sutton on Sea, their appendages of Trusthorpe and Sandilands, and the straggling settlements near Chapel Point and Ingoldmells Point.

The serious loss of life was due especially to the critical depth of the floodwater, which, although not above 2 or 3 feet well inland was much greater near the coast. At Anderby Creek, which was flooded from a breach well to the north the water-level inside a window was 15·8 feet O.D. where the ground level was 11·15 feet. In the fields nearby where ground level is lower the water at its maximum must have been well over 6 feet deep. In Mablethorpe, Trusthorpe, Sutton and Sandilands the streets are often as low as 7 to 8 feet O.D. The dangerous depth of 6 feet or more was attained along considerable sections of the immediate coastal strip, both near the serious breaches, and elsewhere seaward of the Roman Bank.

The older Outmarsh villages, apart from those at the coast, are generally sited on hummocks of boulder clay, secure from floods, for example Mumby, Hogsthorpe, Huttoft, Strubby, Beesby and Anderby (see Fig. 1). The coastal villages may themselves have been sited originally upon boulder clay hummocks or upon siltier patches like the tofts further south; these have now been eroded away by the sea. It is unfortunate that the holiday industry has attracted a large population into the most dangerous area near the coast, and most recently into the area seaward of the Roman Bank which is liable to especially deep flooding.

To the farming community the effects of the floods are likely to

be serious. Although losses of livestock in Lincolnshire were small, damage to the land was widespread, for the briefest inundation by sea water impregnates the soil with salt, and prejudices crop growth. In addition to over 7,900 acres of improved (and often high grade) grassland, and 460 acres of rough grazing, nearly 13,400 acres of productive arable land scheduled for cropping this year were flooded in Lincolnshire. In the Outmarsh the sluggishness of soil and land drainage makes sea-flooding particularly serious. The long dry spell following the floods has denied to the land the advantage of flushing by rain, and it may be found that land which was not actually covered by salt water is adversely affected. The dykes in this flat district were filled with sea water which may have penetrated through field drains to impregnate the surface soil from below.

Damage caused by sand washing inland is localised. The greatest penetration occurred in association with the major breaches through which sand was carried to form well-defined deltas in the standing flood water (Plates I and III). Sand filled many of the streets and gardens of Sutton, Sandilands, Trusthorpe and Mablethorpe, often to a depth of 4 feet or more, and its removal is difficult, but the area of agricultural land affected in this way is inconsiderable.

In the most southerly and extensive area of flooding the importance of breaches in the defences has been emphasised. Wave action here was much more severe than further north. The coastal damage along this part of the coast, from Saltfleet southwards has been studied in some detail.

Coastal damage between Gibraltar Point and Saltfleet, in relation to the character of the beach and sea defences

The area between Gibraltar Point and Saltfleet comprises coasts of accretion north of Mablethorpe and south of the north end of Skegness, with the intervening section a coast of erosion. The following discussion elaborates the significance of this sub-division.

Twenty-three beach profiles have been surveyed, those south of Ingoldmells about a week after the storm, and the remainder three weeks later. They cover a stretch of coast along which damage ranged from insignificant scouring of small foredunes to the complete destruction of massive sea walls. The profile features (Fig. 2) show a striking correlation with the intensity of coastal damage which emphasises the great importance of the form of the beach as a factor in erosion, as well as one of its results. Each profile was surveyed from the foot of the dunes or the base of the sea wall. The profiles fall into groups having similar characteristics.

I. Profiles 1 to 4, between Gibraltar Point and Skegness, are similar in height. A high upper beach serves to protect high, well-vegetated natural dunes. Under normal conditions the beach is of ridge and runnel type on account of its width. The ridges diverge from the coast southwards at a low angle, and migrate southwards bodily; at any point on the coast they therefore appear to move shorewards. This movement (which measurements over two years

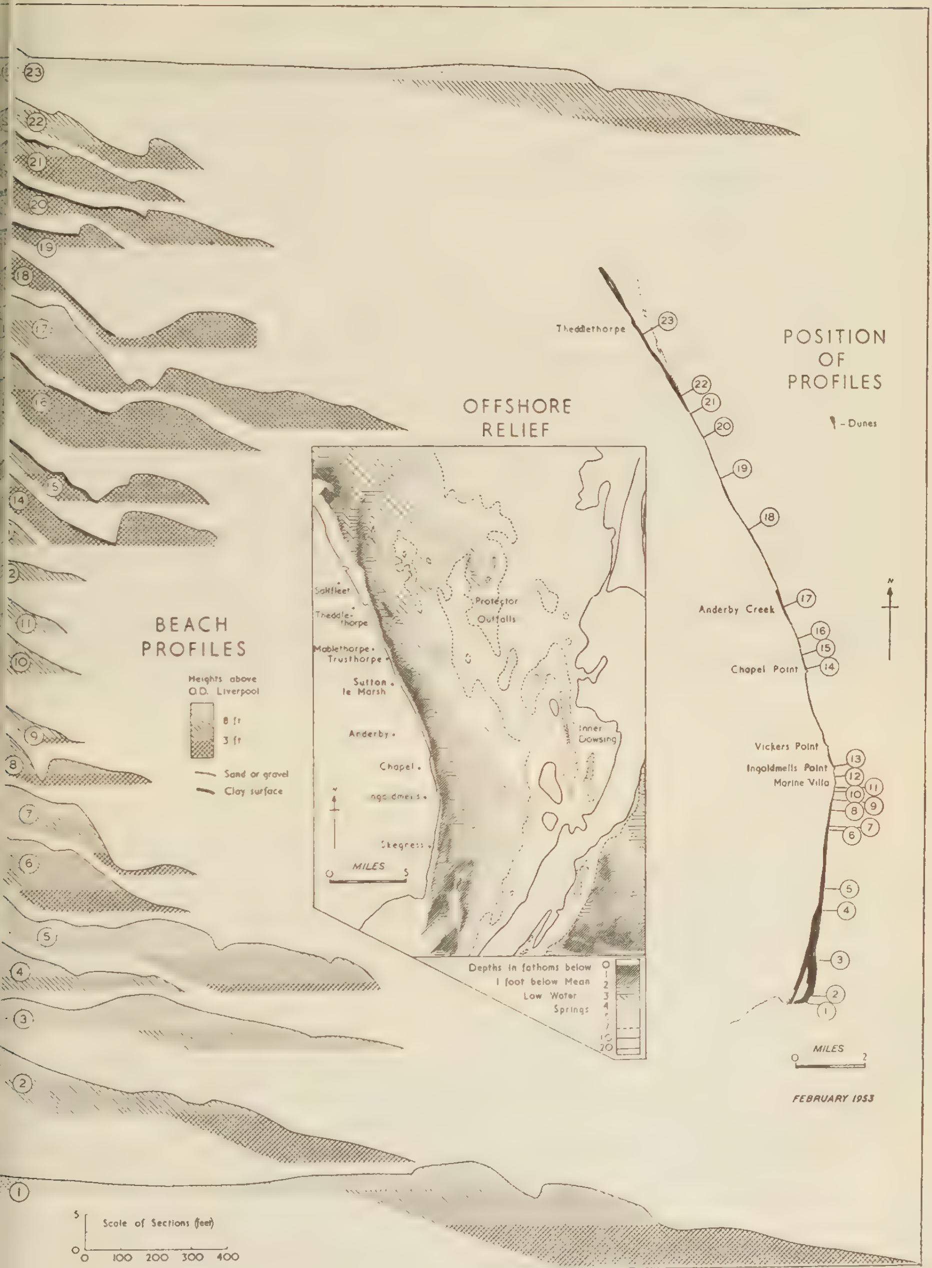

Fig. 2.—Lincolnshire coast : beach profiles and offshore relief.

indicate to be normally at a constant speed, of the order of 70 feet per annum) transfers sand southwards, while adding to the upper beach as each ridge passes. Parallel lines of new dunes have grown on the

widening upper beach during the last few decades. No artificial defences are necessary, and damage was slight. The marsh behind Gibraltar Point, and land along the lower Steeping River were flooded from the south, and the storm beach at Gibraltar Point was overtopped, but the only damage at the Point itself was relatively minor dune cliffing. A little further north cliffs 6 to 10 feet high were cut, and the foot of the frontal dunes receded by about 30 feet, but near profile 3 damage was confined to scouring of the small dunes on the upper beach, and the main dune line was untouched. Dune cliffing occurred again at profile 4, where the activities of holidaymakers have prevented the growth of foredunes.

II. Profile 5 was surveyed from the centre of Skegness front, where natural dunes have been replaced by promenades, and dunes are not permitted to grow on the beach. The high and wide upper beach, by absorbing wave energy, and causing the waves to break well offshore at high water, saved Skegness from serious damage, for the top of the pullover (18·3 ft. O.D.) and the promenades are critically near the high water level, and waves broke over them, doing some damage. Flooding was shallow, and confined to an elongated area of reclaimed dune slack.

III. Profiles 6 and 7, at the north end of Skegness, are intermediate in character, showing a narrow berm at a fairly high level, probably built from eroded dune sand. The dunes are narrowing here, but still form a substantial barrier. The bench of sand reduced the violence of wave attack, and damage was restricted to dune cliffing.

IV. Profiles 8 to 13 cover the section from the southern end of Butlin's Holiday Camp to just north of Ingoldmells Point, along which damage was increasingly serious northwards because the dunes become increasingly attenuated ; here the most southerly major breaches occurred. This group of profiles shows a significant change of type ; the beach becomes steeper and narrower, and it becomes lower. Deep water therefore occurs nearer the shore at high tide, and large waves breaking high up the beach expend all their energy upon a narrow zone near the water line. The first complete breach occurred at profile 10, where narrow, low dunes were swept away, and a clay-faced bank exposed. At profiles 12 and 13 a substantial sea wall was virtually destroyed between the Points of Marine Villa and Ingoldmells. A fairly high, though narrow dune line occurs north of Ingoldmells Point, but it was breached immediately south of Vickers Point, and

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Plate I.—The Acre gap between Sutton and Sandilands (Lincolnshire) at low tide ; a major breach behind which a sand delta was formed. The dune end at the south side of the gap indicates the quantity of sand shifted.

Plate II.—Six Marshes (Lincolnshire) on the south side of a wide gap. Clay is exposed on the foreshore ; behind the flimsy sea-wall, the damaged bungalows stand on a low, eroded dune. The Roman Bank separates the partially flooded fields inland from the flood water whose surface is here 6 ft. lower than its maximum level.

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again further north. A wide breach was opened in this section near Trunch Lane, Chapel. Where the dunes were not breached they were seriously cliffed. The clay foundation of the beach was exposed in front of the dunes and walls by seaward scouring of the sand (see profiles 9 to 12). Sand later returned slowly as a thin partial veneer under the operation of normal forces. The Points, faced by iron or concrete, were very severely damaged.

V. Profiles 14, 15 and 16 were surveyed along a section of coast which has suffered repeatedly from breaching in the past 150 years, and where the dunes were partially destroyed in 1949 (Six Marshes). A concrete wall was demolished (profiles 15 and 16), although the stout iron-faced defences just north of Chapel Point suffered less (profile 14). Houses on the dunes behind profile 15 were wrecked, and north of Sinclair Villa there was a complete breach over half a mile long. In each profile the beach is low, which accounts both for the need for a sea wall, and for the successful attack made upon it by storm waves. Impermeable clay forms the foreshore. The sand ridge on the lower beach may have been built up between the storm and the survey.

VI. Profile 17, surveyed just north of Anderby Creek Outfall, again shows a high platform of sand, which afforded some protection to the coast. The sand was derived in part from the dunes which were severely cut back into cliffs about 20 feet high, leaving houses precariously situated at the extreme edge of a high sand cliff. There was no breach in the defences because for about half a mile north and south of the settlement the dunes are higher and wider than those beyond. This section appears to have been relatively spared by erosion for some centuries.

VII. Profiles 18 to 21, considerably lower than any of the others, were surveyed in the section where damage was most severe. They extend from the foot of the sea wall at Sandilands (Sea Bank Farm), Sutton on Sea, Trusthorpe and Mablethorpe respectively. Clay is exposed on the foreshore in each profile, there is no upper beach above high neap tide level, and the beach is narrow, even at low water. The level of the beach immediately below the defences at Sutton and Trusthorpe is 4·6 feet O.D. The massive sea walls required here suffered badly from the storm waves. In many places they collapsed because overtopping cut away the narrow dunes behind and beneath them.

Plate III.—The breach in the stepped sea-wall at Mablethorpe (Lincolnshire) and extensive flooding to the west and south. An emergency sand-bag wall is under construction across the wide sand delta which extends into the streets of the town. A second gap and sand delta lie, in the middle distance, behind the large building on the sea front. Artificial cuttings of an earlier period are discernible in the clay exposed on the foreshore at low tide.

Plate IV.—A view looking northwards across the Mablethorpe breach (above) over the demolished sea-wall. The narrow dune behind the wall has been completely removed to the depth of the breach, while the rear of the wall has been undermined by the washing out of its sand foundation.

The dunes in this section were exceptionally narrow. They suffered a major breach south of the end of the sea wall, near Elder Cottage (see Fig. 1). Another breach occurred near Sea Bank Farm (profile 18). Between the two breaches the sea wall held, although the dunes behind were eroded by water washing over the wall. The most seriously damaged part of the coast, between Sea Bank Farm and Mablethorpe, is entirely protected by concrete walls which were broken almost throughout (especially where they were of the stepped variety) and were completely demolished in a number of places. There was a complete breach just south of Sandilands, and another more than 300 yards wide, the famous Acre Gap, between Sandilands and Sutton. North of the Acre Gap there were many partial, and a number of complete breaches. These were all at a low level because the upper breach is low, and were responsible for the very wide flooding of the Outmarsh behind.

VIII. Profiles 22 and 23 show a return to conditions similar to those found in the southern area of accretion, the change taking place somewhat abruptly north of the centre of Mablethorpe, where the dune belt becomes more extensive, and the beach much higher and entirely sandy. Concrete defences are discontinued, and, although cliffed, the dunes have withstood the storm. A well marked sand ridge appears on the beach towards the northern end of Mablethorpe (profile 22). Profile 23, at Theddlethorpe St. Helen, two miles further north, is in even more striking contrast with profiles 20 and 21. The great extent of sand at a high elevation, whose rippled surface testifies to the weakness of wave action in the swash and backwash zone, has afforded adequate protection to the wide dune belt, which rises generally to 30 feet O.D. These dunes, built by the wind from sand exposed on the wide upper beach even at ordinary high tides, are well vegetated, and afford a striking contrast with the meagre dune line a few miles to the south. They protect the inland areas as far north as Saltfleet Haven.

This summary shows that there is a striking correlation between the incidence of damage, the form of the beach and the type of sea defence, but the relationships between these features are not simple. An obvious generalisation is the coincidence of slight damage with wide dunes above a wide, high beach. Dunes are maintained by sand blowing from the supply accumulating on the foreshore by constructive marine action. They constitute a reserve of sand which destructive storm waves can comb down to form a protective berm, which breaks the force of the waves, and so minimises the further erosion of the dunes. The steep, low beaches of the damaged section are associated with a thin, low dune line, which has needed much reinforcement with concrete, and which has suffered severely from the storm, even when thus artificially protected. The effects of sea walls are discussed further below, but, in general, the long term factors causing slow differential erosion and accretion along this coast have prepared the way for the varied action of the abnormal forces operating

in time of storm. As is the case with erosion of other types (cf. the Lynmouth storm[7]), it is usual to find along coasts of this type that the occasional short term operation of violent forces accomplishes in a very short time an inordinately large amount of geomorphological work. What we here see is an instance of the mechanism by which the Lincolnshire coast has retreated spasmodically in some sections through the past centuries.

Restoration

Restoration of the coastal defences involves two phases; an emergency stopping of the breaches, to be followed by the planning and implementing of a long-term, comprehensive policy for coastal defence. Restoration in the flooded areas similarly implies immediate measures to dispose of floodwater, followed by the longer process of restoring fertility to the soil.

The emergency operations in the Lincolnshire coastal area were a remarkable achievement. The serious breaches were repaired with great speed between the flooding and the succeeding spring tide period a fortnight later, as a result of a massive mobilisation of men, machines and material. In the sections of serious dune cliffing, sandbag walls were built in front of the dunes. Elsewhere it was necessary to reinforce, and often completely to rebuild the defences. The operation involved strengthening the Roman Bank, and patching the coast defences proper. Where the Roman Bank forms an effective second line of defence north of Chapel Point, repairs to the actual coastline could be postponed, and the bank became temporarily the effective coast[8]. North of Sandilands, however, there is no second line of defence to contain the water flooding through the breaches, and water could readily extend laterally behind the Roman Bank to the south, and behind the dunes to the north. This was therefore a critical section, especially in view of the dense coastal settlement there, and it was necessary to fill the breaches along the coast itself, where there is no elevated beach to prevent the sea from washing the defences at all periods above half tide. This difficult but vital major work succeeded through the use of a great concentration of lorries, draglines, pile-drivers, bulldozers and other heavy equipment, which gave to the quiet fronts of the small resorts an aspect reminiscent of the skyline of a major port. An immense quantity of Scunthorpe slag, chalk and other rubble brought in from many parts of the country, was dumped to form a wall which was faced on the sea side with rough concrete. Such walls have served their immediate purpose, and have been strengthened.

Despite satisfaction that the temporary defences have withstood the high tides of a notably quiet late winter period, it is not to be expected that they will survive a severe storm that coincides with a high spring tide. The extent to which the Lincolnshire coast defences

[7] See C. Kidson and J. Gifford, "The Exmoor Storm of 15th August, 1952," *Geography*, vol. xxxviii, 1953, pp. 1–17.

[8] A new coastal bank was being constructed in this section in early April, 1953, using clay excavated from the Marsh behind the inner bank.

have been destroyed presents an opportunity for replanning them as a whole, on a long-term basis. The great capital outlay involved demands that such replanning shall improve upon past conditions. This will require consideration, not only of engineering questions, but of the whole problem of erosion on this coast, viewed in the widest possible geographical context, and assessing, as far as possible, the results of the interaction of all the various natural forces involved. This article therefore concludes with a statement of some basic problems which require urgent investigation on this section of coast.

Some Coastal Problems of Lincolnshire

The individual problems demanding investigation fall broadly into three groups. Most of the first group are essentially questions of geomorphology, the second group includes engineering questions like that of the most suitable design and material for sea walls, the third comprises social problems such as planning control of development in dangerous areas. Only problems of the first group can be considered here.

(a) *Beach Development*

Dunes and sea walls, and combinations of the two, must be considered as defences together with the beach which fronts them. There is the closest correlation between the height and width of the beach, and damage to the coast. The controlling factors in beach development are marine.

Offshore relief may have a bearing on the incidence of erosion, and in order to test this possibility for storm conditions wave refraction diagrams have been constructed for large waves approaching from north-north-west or north, the direction of longest fetch. The result was inconclusive, for the areas of coast showing maximum convergence of orthogonals, and therefore theoretically subject to maximum wave attack, were not those most seriously damaged. The character of the beach seems therefore to be the controlling factor determining the differential effect of storm waves ; this character is shaped under the influence of normal marine forces. Since the whole beach is underlain by relatively resistant clays and peat at a reasonably constant height, it becomes necessary to establish the nature of the normal forces which control the distribution and movement of the loose surface cover of sand and shingle. Wave refraction diagrams have not yet been constructed for " normal " conditions.

The coast from Cleethorpes to Saltfleet is sheltered by Holderness and Spurn Head. From Mablethorpe southwards it runs in a fairly uniform direction, with minor curves, to Ingoldmells, and along this section sand transport appears to take place without interruption, apart from the effect of the manifestly inefficient groynes. At Ingoldmells Point the orientation changes significantly, so that sand is more likely to accumulate to the south, where the coast is partially protected from the north. Material deposited here will tend to straighten the coast, a process which is exhibited on a smaller scale

at Gibraltar Point, where a spit continues the line of the coast southwards.

The movement of beach material by the sea is also affected by the direction and speed of the tidal currents. While the current before high tide flows generally from the north, there must be some differentiation of speed and direction along the Lincolnshire coast on account of the presence of the Humber and the Wash. The tidal flow diverges immediately south of Spurn Head because some water flows up the Humber ; this should lead to a reduction in the velocity of the current on the northern part of the open coast north of Saltfleet Haven. This is considered partly responsible for the outgrowth of the coast about Donna Nook and in the vicinity of Saltfleet. The zone of accretion extends south as far as Theddlethorpe. The meeting of the south-moving ebb current from the Humber, and the north-moving ebb along the open Lincolnshire coast may enhance the tendency to accretion here. Further south the current flows parallel to the shore, and is stronger due to convergence induced by the orientation of the coastline. Between Mablethorpe and Ingoldmells the stronger currents readily move southwards along the beach the material thrown into suspension by the stronger waves at and before high tide. Considered in relation to the coast as a whole therefore, this area has a net deficit of sand, for on the average a high percentage of that moving into the area from the north is transported southwards along the beach ; little of it goes to reinforce the dunes, and there is much clay exposed on the foreshore. In some periods, after a spell of constructive wave and wind conditions, usually in summer, sand accumulates on the foreshore, but it is only a temporary veneer. There is little possibility of its permanent accumulation on a narrow beach in front of a sea wall on the open coast. Quantitative measurements of the volume and rate of sand transport at different points along this coast are desirable, but entirely lacking.

(b) *Dune Growth and Decay*

Natural dunes grow and are maintained solely by the blowing of sand from the beach. In the areas of accretion an adequate supply of sand, high enough to dry out at low tide, permits the growth of high, wide and well-vegetated dunes, the extension of which may often be readily induced by the planting of sand-fixing pioneer plants or by other means[9]. In the areas of severe wave attack, where beach material is in short supply, there is usually only a temporary and discontinuous layer of sand on the beach from which dunes might be naturally reinforced, and it is often at such a low level as to be normally wet, and not subject to movement by wind. The dunes are therefore usually low and narrow. Treading of such dunes, inhibiting the growth of binding vegetation, is a serious matter, and in recent decades it may have been an important factor leading to the establishment

[9] For example, near Saltfleet a coastal strip was reclaimed about 1856 by "fixing a line of fascines to arrest the sand which blows off the shore . . : when once started the sand continues to accumulate . ." A. J. Jukes-Browne, 1887 *op. cit.*

of an increasingly unstable condition in which loss of sand by blowing from the dunes has come to exceed the natural supply. This is a cumulative process, for marram, and sea lyme grass, the long roots of which act as sand binders, and the stems as sand traps on the seaward face of the dunes, tend to degenerate when the dunes cease to grow. Some of the breaches appear to have developed at points where the dunes were weakened by trampling in this way. More information is needed on the present dynamic state of the natural dunes at points along the coast and what biotic factors have operated in the immediate past.

(c) *The Effect of Sea Walls*

Where the dunes have failed, or appeared likely to fail in the recent past, artificial defences have been built. Wooden structures of basket-work or plank platform types, some of which encouraged sand accretion, and which were moderately flexible, have in recent years been replaced by rigid concrete walls of various designs. It is no coincidence that where concrete defences have been built they have needed strengthening, and that the sections of coast requiring such defences has been quickly extending. Such walls lack any form of flexibility, and it is highly likely that their establishment in some places has seriously jeopardised adjacent areas. Once such a wall is built it is almost certain to cause an accelerated deterioration of the beach in front of it. There is no reserve of sand to be combed down to raise and cushion the upper beach, and absorb a portion of the swash and backwash through its porosity. The abrupt barrier presented by the wall to the advancing wave causes an undertow to develop which is stronger than that on the natural coastline, particularly with onshore winds, and this readily scours material down the beach, to expose the impermeable clay on the foreshore. Once this condition is established it must be difficult to reverse, for the more powerful wave action in the deeper water actively erodes the clay itself, and once lost this is irreplacable. It would appear that sea walls on open low coasts favour a system of destructive forces which is likely to damage the coast in a cumulative way. Much knowledge remains to be gained on the effects of sea walls from this point of view along this particular coast.

The inflexibility of sea walls and their associated low clay foreshore may increase the danger of erosion of nearby dunes, for at high tide some wave energy must be transferred along the wall to undefended places, which are attacked on the flank. The reality of this effect was apparent from a study of the positions of the breaches effected in this storm. Walls also hinder or prevent natural reinforcement of dunes behind them, condemning the dunes to botanical degeneration, and eventual erosion by wind.

The stepped type of concrete wall has proved to be unequal to the demands made upon it along this coast, and has readily disintegrated. The latest type of sea wall has in some sections been more successful. It has a seaward face concave at the top which diverts

some part of the breaking wave seawards, thus reducing the amount of water washing over the wall, and the erosion of the dunes behind. In parts it has been destroyed or damaged like walls of other designs, because it has been undermined in the rear in a similar way. One lesson from this storm is that walls of the height of those at Sutton and Mablethorpe, whatever the design of their seaward face, are unreliable so long as they are backed only by material which is easily eroded by overtopping water, so that the unsupported concrete facing collapses through wave pressure from seaward. Increasing use is now being made of interlocking iron piles driven deeply into the clay foundation of the beach.

(d) *The Effect of the Points*

The minor configuration of the coastline appears to have had a direct bearing in some sections on the positions of breaks from which damage extended. Although simple in broad outline the Lincolnshire coast is complex in detail, largely due to the construction of sharp, artificially defended Points, usually near to the outfalls of drainage channels, and possibly designed to prevent silting of the outfalls by beach material. Some of the Points may originally have been natural promontories due to boulder clay hummocks. They appear to affect the movement of beach material in such a way that the beach on either side, but particularly on the southern, or lee side, is lowered by comparison with that on the neighbouring straight coast. This may be due to the sharp deflection of waves round the Points, which protrude so abruptly from the general line of the coast that a normal beach cannot develop in front of them. Even in normal times Chapel Point has a deep pool on both the north and south sides of the iron and concrete wall. The same effect was seen on the south side of Ingoldmells Point three days after the storm, when the upper beach was very low. A few days later a very deep pool was cut off from the sea by the growth of a shingle bank extending south from the end of the promontory, well seaward of the back of the beach. These pools and areas of low beach are due to tbe interception and deflection of wave-transported material moving south along the coast, and to the scour of the steeper waves below the artificial defences. Thus on account of the sharpness of the Points the beach contours are concave to the sea instead of following the convexity of the wall. The result of these beach conditions is that an exceptional concentration of wave energy is expended on the defences of the Points, and wave energy is increased in their vicinity by the convergence of orthogonals due to wave refraction round them. Many breaches occurred immediately south and north of such defended Points and in replanning the coast defences particular attention needs to be paid to this problem.

Conclusions

(i) The inundation in Lincolnshire has been shown to be the latest of a long series, and increasingly elaborate measures may be needed to combat the menace of flooding on account of the slowly rising sea

level, and the dangerously low level of the beach where erosion is most severe.

(ii) While the best defence is a broad belt of high, well-vegetated dunes, fronted by a wide high beach, this condition is not permanently attainable everywhere along the Lincolnshire coast, for reasons already discussed. It is significant that sea walls are detrimental to the growth of dunes, but where dunes are now absent such walls are essential to the safety of the coast.

(iii) Some re-alignment of the coast might help to stabilise conditions, and enable a naturally protective wide beach to be established in some sections. The formation of such a beach is the fundamental problem for which a solution is desirable though geomorphologically it may prove insoluble. Without such a beach natural dune defences cannot permanently exist. A coast lacking a protective natural beach is inherently unstable, and subject to geographical change over a relatively short span of time ; it cannot be completely stabilised by natural or artificial means. The best that can be hoped for is a compromise with the forces of nature favourable to the human exploitation of the area.

(iv) In this respect an important safeguard for the Outmarsh might be provided by building a continuous strong inner bank behind the present coastline, joining with the sections of the Roman Bank already in existence to act as a second line of defence. Ideally all areas seaward of such a bank should be regarded as a part of the defences, and no permanent settlement should be permitted there. Future development of the holiday industry might conceivably be directed to the sandy coast of accretion to the north, where safer sites for settlements exist.

It is clear that a comprehensive study of coastal processes in Lincolnshire is one of the first essentials to the planning of coast defences on a regional scale.

Plate V.—The damaged jetty and remains of the lighthouse, Margate Harbour, Kent.

Plate VI.—Heavy seas pounding the concrete promenade on the north side of Chapel Point, Lincolnshire, at the time of the flood disaster. (Acknowledgment is made to the Editor of *Survey*, University of Nottingham, who kindly loaned this block.)

Plate VII.—The breached sea-wall and the flooded marshes of the northern Wantsum Channel, Kent, with Reculver Church in the distance.

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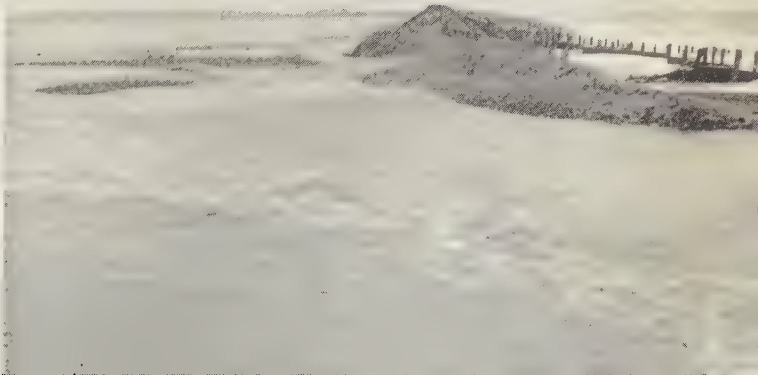

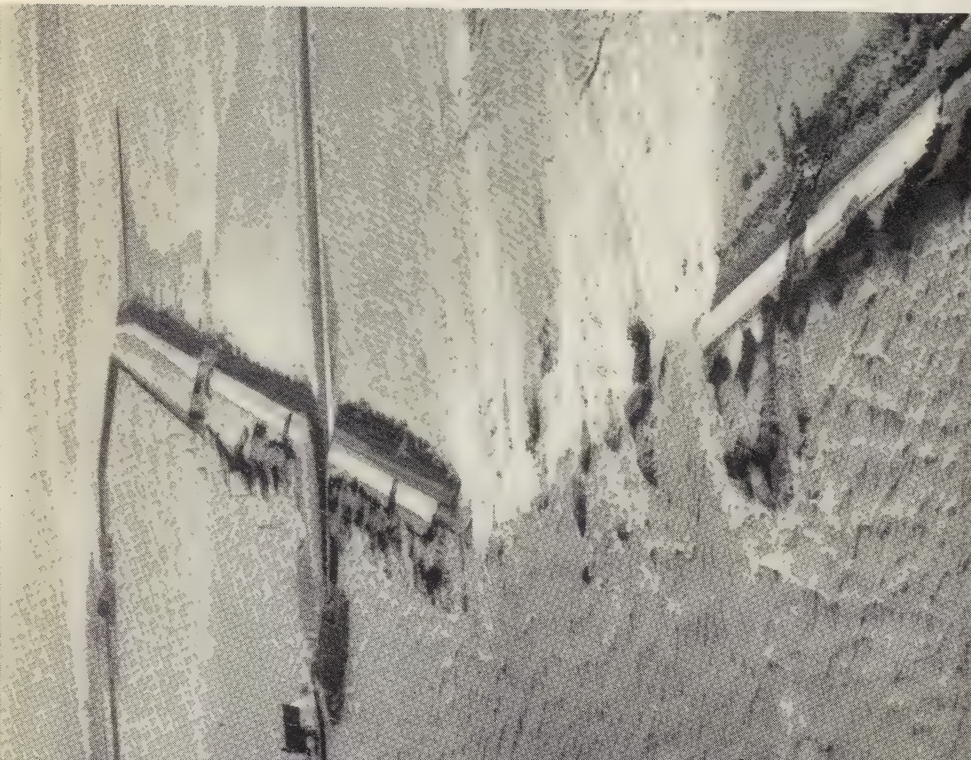

III.—A NOTE ON THE RIVER TRENT

K. C. EDWARDS*

THE Trent, like other rivers of the central lowlands of England, is subject to periodic flooding. From this standpoint the river may be divided into three sections. Upstream from Newark floods are mainly due to the swift discharge of the tributaries Churnet, Dove, Wye and Derwent, into the mainstream following prolonged heavy rains or rapid snow melt over the higher parts of the catchment area. Districts especially liable to inundation from this cause are those of Burton-on-Trent, Derby and Long Eaton—Nottingham. From Cromwell Lock, a few miles below Newark, the Trent is tidal and downstream from this point as far as West Stockwith, four miles below Gainsborough, serious consequences may result from a coincidence of a high river (following exceptional rains) and spring tides. This combination of fluvial and tidal high water provides the conditions for maximum flood liability. From the standpoint of damage and loss to property, Gainsborough is the only vulnerable town in this section of the Trent although important agricultural areas are liable to suffer severely. Below West Stockwith the effect of fresh water discharge is negligible and flooding can only arise from abnormal tide conditions which are rare. The care of river banks in the lowest section is of utmost importance however, for the mean level of the surrounding land is 4 feet below that of high water at ordinary spring tides.

Of major floods in past decades those of 1875, 1910, 1932 and 1947 were the most severe. Among the more recent, that of May 1932 was primarily due to exceptional weather conditions and chiefly affected areas along the non-tidal stretch although a serious breach of the bank occurred at Cottam between Newark and Gainsborough. In March 1947 a high river combined with the equinoctial spring tides resulted in extensive flooding along the tidal section, the area of inundation being vastly extended by a formidable breach 282 feet long in the bank at Morton made by the night tide of March 27th, through which water poured unhindered for several days, submerging a tract of country some 15 miles long and reaching as far north as the low-lying district west of Scunthorpe.

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Plate VIII.—A gap in the sea-dike near Dinteloord, West Brabant, Netherlands, illustrating the sapping of the inner face of the dike. In places concrete blocks have been washed off the seaward face. In larger gaps, the tidal currents have, since February, scoured channels of up to 37 metres depth. The channel in middle distance is the outlet of a waterway.

Plate IX.—Repair work on a small gap in Schouwen-Duiveland, Zeeland, Netherlands. Boulders are unloaded from barges, while sand is pumped to the rear of the repair dike through pipes (centre) from a dredger lying offshore. In July, 1953, more than half of this island lies under tidal water and at low tide resembles the polder shown in the photograph (right).

Both photographs are reproduced by courtesy of the Central foto-library, Netherlands Government Information Office, The Hague.

On the occasion of the disastrous storm surge of Jan. 31st—Feb. 1st 1953, although this also occurred at a period of spring tides, there was virtually no flooding along the Trent. There was no overtopping of the banks and the only breach was near Alkborough just above the Humber confluence. Here a small break in a section of floodbank known to be vulnerable and in any case due for repair, caused a few acres of low-lying grazing land to be temporarily submerged.

The chief factors affecting flooding on this occasion would appear to be the level of fresh water discharge in the river and the storm surge in the North Sea. As to fresh water discharge, the Trent was at a relatively low level at the time of the storm owing to the preceding dry weather. January was a month of light rainfall and at Nottingham, where the mean total for the month is 1·74 in., only 0·86 in. was recorded, of which 0·42 in., or nearly one-half, fell on the 30th. On Jan. 31st the level of the Trent as shown by the permanent recording gauge at Nottingham stood at 68 ft. 6 in. above O.D. (Liverpool), which is exactly the mean winter level. The rainfall of Jan. 30th produced but a slight effect for after 8 p.m. on the 31st it rose during several hours to 70 ft. 6 in. and remained at that height until the following afternoon when it fell again. A much greater rise would be required to affect the level in the tidal section. Even with spring tides therefore, the condition of the river itself, being normal for the time of the year, was unlikely to cause flooding.

The North Sea surge, which might be assumed to have been the more important factor, was also negligible in its effect. According to records taken at successive points along the Humber and the lower reaches of the river, the surge, so effective in raising the tide level along the open coast, failed to influence the height of the tide in the Trent. On the accompanying diagram (Fig. 1) the graphs (based on readings at the places named) show the maximum level reached by the tide of Jan. 31st–Feb. 1st and that of the tide of Feb. 16th during the next period of springs. Unfortunately no really reliable graph of the predicted tide for Jan. 31st–Feb. 1st can be constructed but it can be assumed that had wind conditions not been abnormal, the H.W. figures in the river itself for Jan. 31st–Feb. 1st would have been a few inches lower than those actually recorded on Feb. 16th.

From this evidence it is clear that the surge produced a marked effect in the lower Humber. At Grimsby the highest level recorded was 15 ft. 8 in. above O.D.[1], whereas under normal spring tide conditions it would have been under 12 ft. 0 in. at H.W., thus indicating that the surge raised the maximum water level by about 4 ft. Figures for Immingham supplied by the Ministry of Agriculture show that the height of the surge at the time of predicted H.W. was 5 ft. 6 in. but the gauge was admitted to be "partly defective." Apart from this instance the surge, as shown by the graphs, exerted a diminishing

[1] This and all heights mentioned later in this paragraph refer to the Newlyn datum.

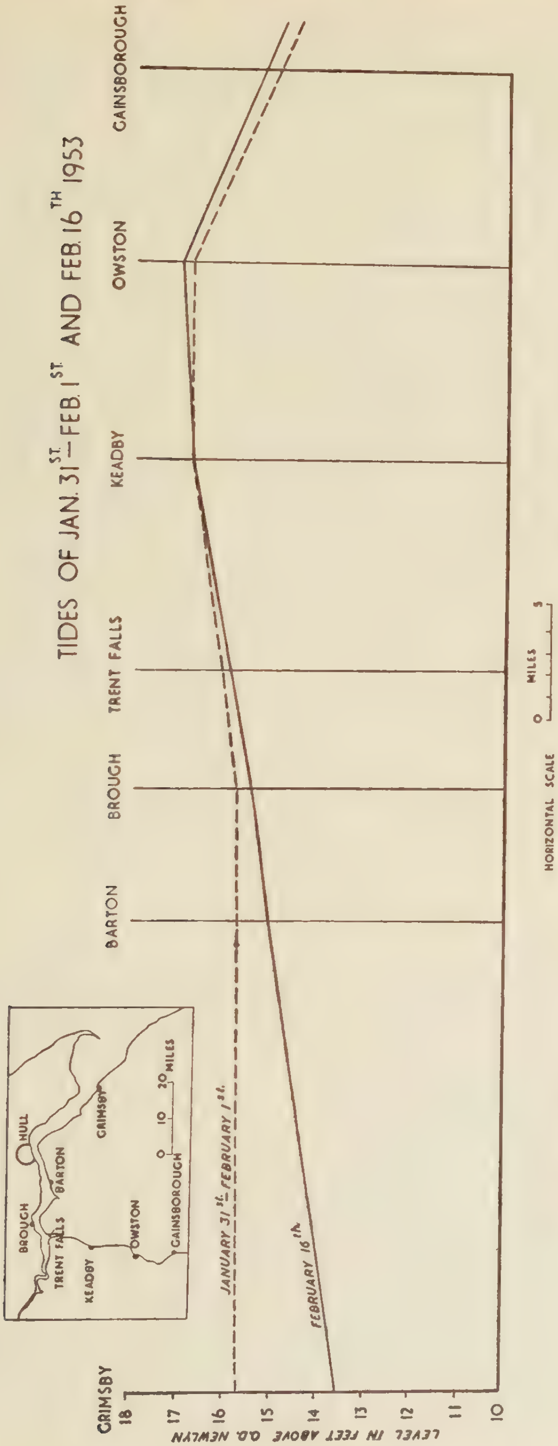

Fig. 1.—Graphs showing maximum water level in the Humber and Lower Trent for the tides of January 31st–February 1st and February 16th, 1953 (based by permission on readings taken by Humber Conservancy Board and Trent River Board).

effect along the Humber and at the entrance to the Trent was insignificant. Upstream in the neighbourhood of Keadby the water level was no higher than that reached by the spring tide of Feb. 16th and further up at Gainsborough it was actually lower.

The explanation of these circumstances is difficult to determine since many variable factors are involved. Records are not as complete as could be wished; careful scrutiny of those available and much subsequent calculation by experts will be necessary before some of the issues are clarified. The fact that the Humber opens seaward in the direction of the progression of the surge may have prevented the piling up of water to the extent that occurred in the Wash and the Thames; the strength of the northerly gale may also have played a part but neither of these possibilities can be confirmed at present.

During the fateful week-end an incidental feature was the reappearance of the bore (*aegir*) which had not been so well developed for a few years past. In other respects the Trent provided a somewhat unexpected contrast to the coast. There was neither abnormal height of water nor exceptional pressure exerted on its banks to test the defences. Even if this had been the case, disaster may have been avoided, for it must be noted that during the past twenty years a good deal of improvement work has been accomplished by the Trent Catchment Board, now the Trent River Board. In the lower reaches banks have been strengthened and in many places their height has been raised; as the programme proceeds so confidence in the ability of the defences to withstand abnormal tidal conditions steadily grows.

IV.—THE SEA FLOOD ON THE COASTS OF NORFOLK AND SUFFOLK

A. T. Grove*

THE coast of Norfolk and Suffolk bulging into the North Sea between the Wash and the estuaries of the Essex rivers is a youthful coast, fashioned out of soft rocks and unusually sensitive to perturbations of the sea. Wide areas have been won from the sea in the last few centuries and old maps show that the cliffs, dunes, spits and marshes have altered comparatively rapidly as a result of artificial reclamation and natural erosion and accretion. It has long been recognised that the secular movement of material in the coastal zone by tidal currents, waves and the wind leads to progressive changes in its conformation; this latest storm and sea-flood emphasises the fact that the work of decades can be undone or in some cases can be greatly accelerated by extraordinary combinations of weather and tidal conditions lasting

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only a few hours. The results of this upheaval cannot be fully assessed, nor will they be apparent, for some months to come. Here, in the meantime, some account is given of the changes which took place during the storm and soon afterwards, with special reference to those areas which are of particular interest or for which quantitative data happen to be available.

The main watershed of Norfolk and Suffolk forms a rough T with the two arms meeting west of Fakenham (Fig. 1). From the East Anglian Heights, forming the stem of the T, streams drain to the coast 30 miles to the east, and to the Ouse 20 or 30 miles to the west. In the lower courses of these comparatively large rivers, in the Broads, the Fenland and along the lower courses of the Suffolk rivers, quite wide areas are at or close to mean sea-level and are protected from the sea at high tide by artificial banks and natural ramparts of sand and shingle. The cross-bar of the T runs east and west within 10 miles of the north Norfolk coast and streams draining northwards from it are short. Along the coast itself the offshore gradient is slight and a strip of marshland, fronted in places by shingle bars and dunes, extends westwards from near Weybourne to the cliffs at Hunstanton, and southwards from there along the edge of the Wash.

The dominant winds are from the north-easterly quadrant. Consequently, long shore drift carries beach material away from that section of the coast where the east-west watershed is terminated by high cliffs, south towards the Thames and west towards the Wash. The stretch of coast between Happisburgh and Sheringham is thus the natural starting-place for any study of this kind. Over a distance of about 15 miles the 100-ft. cliffs have for centuries been retreating, and the individual slips and flows together produce a recession of the order of 2 or 3 ft. per year. Costly defence works, mainly designed to protect the towns strung along the cliff-top, restricted the storm damage. Nevertheless, at both Cromer and Sheringham the concrete aprons at the foot of the cliffs were badly damaged and waves rose to heights where they could attack the sandy slopes above. At Mundesley the sea-wall was undermined at the eastern end and the whole of the promenade was severely damaged. Further south, where the cliffs are lower, waves beat over the top of the cliffs at Bacton, and cut them back by as much as 100 ft. An uncompleted sea-wall at Walcot was outflanked, and the sea attacked the clayey cliffs behind, washing away part of the coast road. Where the sea defences were well-built and maintained, erosion along this wasting north-east corner of East Anglia was not spectacular, but there were many large land-slips both during the storm and in the following weeks, especially in sections of coast between the local defence works. For long distances cliffs have been undercut and the full effects of the storm will be made apparent only as further collapses of unstable faces take place during succeeding months.

West of Sheringham, cliffs of boulder clay and soft Crags resting on Chalk diminish in altitude, and beyond Weybourne they had long

been immune from marine action. Blakeney spit swings out to sea in a direction almost 15° north of west and for a distance of nearly 8 miles forms a rampart backed by drained and undrained marshes in some places over a mile in width. On the night of January 31st, the sea rose 6–8 ft. above the predicted tide level, that is about 14–16 ft. above Ordnance Datum[1] and waves driven by strong northerly and north-westerly winds were able to come into action at unusually high levels. The marshes behind the spit were flooded, waves attacked the old grassy cliffs on the south side of the coast road, causing some falls, and the villages of Salthouse and Cley were extensively damaged[2]. At the height of the tide, Blakeney spit was swamped. Shingle was swept over the crest into the marshes so that the spit as a whole was driven inland by 30 or 40 yds. Old marsh muds, exposed on the foreshore, were broken up into blocks 2 ft. thick and flung on to the the top of the shingle ridge. Dunes at the western end were cut away, lows between the dunes filled with water, and on Far Point two large sandhills were entirely swept away and a channel 10 yds. wide was cut through the shingle on which they had rested. West of Morston, the road and salt marshes were flooded, but damage there was naturally far less serious than on the reclaimed marshes west of Wells where 1½ square miles of farmland were inundated and the railway line thrown off its embankment. The drained marshland lies behind the dunes of Holkham Meals and is protected by dykes on the west side and by a high sea wall alongside the channel leading to Wells Harbour. It is not known for certain where the sea first broke through ; there were a number of breaches and the high sea wall may have given way after the marshland behind had been flooded. On Scolt Head Island there are no artificial defences. A large part of the island was covered by the sea and the dunes were cut away, but not more than 10 or 20 yds. at most. On the landward side, damage to villages and farmland was not very marked.

Along the coast of the Wash south of Hunstanton, sea walls were overtopped and broken in a number of places, and some 10,000 acres of drained marshland, much of it arable, were flooded between Heacham and Downham Market. Here, as elsewhere, sea walls and dykes collapsed on the landward side rather than as a result of direct wave action on the side facing the sea. Between Denver Sluice and King's Lynn, the water rose 3 ft. above the level in the open sea and caused some bank failures and flooding. Fortunately the rivers were not in flood, otherwise there might have been grave damage in the Fenland south of the Sluice.

Turning now to the coast south of Happisburgh we find that in plan it forms a smooth curve but, in elevation, cliffs alternate with stretches of dunes and shingle backed by marshes. The cliffed areas once extended much further seawards ; the intervening valleys have been

[1] The datum used throughout this article is Newlyn.

[2] The spit was breached almost opposite Salthouse. The gap was only about 30 yds. wide and has since been filled.

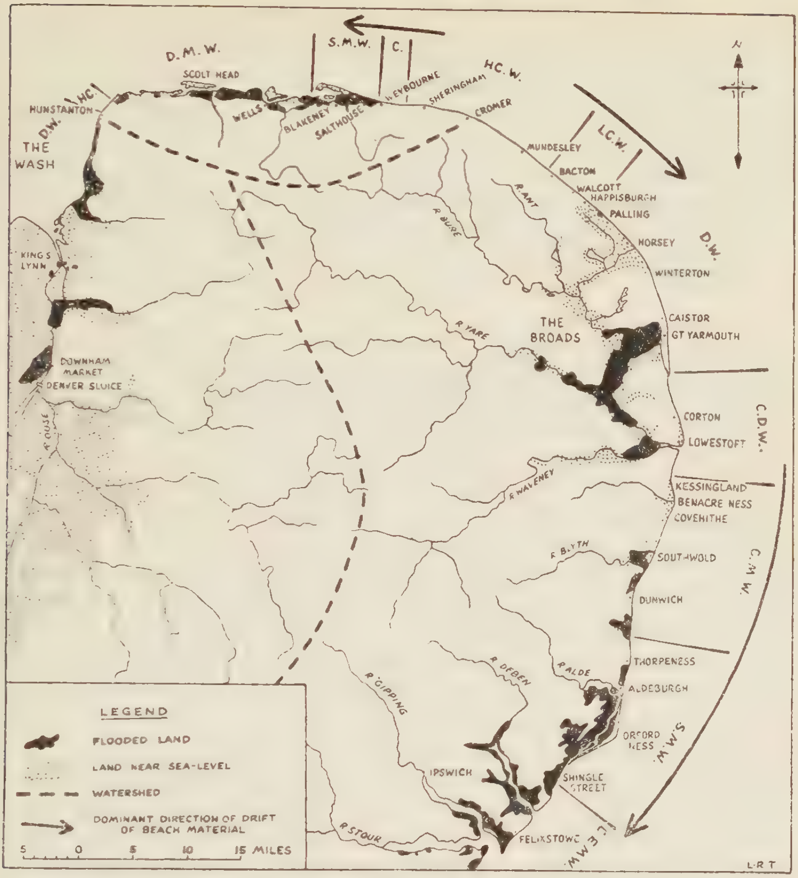

Fig 1.—The Coast of Norfolk and Suffolk.
D—dunes; W—sea walls; M—salt marshes; S—shingle spit; C—cliffs; HC—high cliffs (over 50 ft.); LC—low cliffs (less than 20 ft.); E—estuaries

sealed off by debris carried alongshore from the eroding cliffs and, probably, by material derived from the bed of the North Sea. The area surrounding the Broads is parted from the sea for several miles by only a single line of dunes. At Palling there is no sea wall and the sea broke through at a low point where the dunes were crossed by a footpath. It made a gap about a hundred yards wide and poured in, wrecking part of the village and laying down a spread of sand 5 ft. thick. Flooding inland was not as serious as might have been expected. The most serious aspect of the situation is that the sea has advanced inland on a wide front by 40 yds. or more, sweeping away two-thirds of the total thickness of the dune defence line and leaving only a razor-back ridge of sand which would surely have been entirely demolished had the attack continued a little longer (Fig. 2). On both sides of Palling, at Eccles and Horsey, concrete sea-walls were very badly damaged. The waves over-topped them, and cut away the dunes behind ; at Eccles, the wall collapsed over a stretch

of about one and a half miles, but the sea did not break through. Beach material was combed down all along this coast by the storm. In succeeding weeks, an offshore bar with its crest approximately at the level of high water of spring tides has been moving steadily inshore. At Eccles, it had advanced well up the foreshore by the end of March, and at Palling was still separated from the shore by about 200 yds. of water at high tide. It seems quite possible that the beach will soon be restored to its former condition, though in a position further inland ;

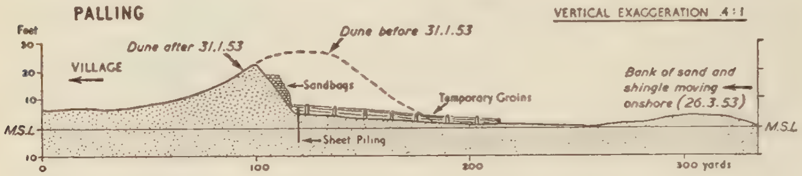

Fig. 2.—Erosion of dune line at Palling, Norfolk.

a long time must elapse before the dunes recover their former size under the action of onshore winds carrying sand from the intertidal zone. Emergency measures have been taken but, for future safety, the seawall is to be extended along the entire dune front from Eccles to Horsey. South of Horsey, accretion has been the rule for some decades near Winterton Ness[3] and the new dune area offered sound protection from the storm. The new sea defences held well at Caistor and damage there was comparatively slight.

At Yarmouth the front was damaged. The centre of Lowestoft was flooded and a number of breaches were made in river-walls and dykes further inland. The position of the top of sandy cliffs at Corton remained unchanged as a result of the storm, but the base of the cliffs was cut away and in subsequent weeks numerous slumps occurred. These slumps are at intervals of about 30 ft., arcuate in plan, and separated by buttresses giving the cliff a scalloped form. Between Lowestoft and Southwold low cliffs of mixed sandy and clayey beds are broken at intervals by marshy valley floors. A mass of sand and shingle called Benacre Ness is year by year moving slowly north ; as it progresses up the coast it first blocks drainage channels and then moves on, leaving the marshes poorly protected with high-water mark further inland than before its passage. South of the Ness, the sandy cliffs near Covehithe retreated in some places by as much as 20–40 ft. as a result of the storm leaving a stepped platform cut in sandy clays at the foot. A month after the storm high tides were still advancing close to the new cliff-foot but the platform was gradually being clothed with shingly beach material. Between the cliffs and the Ness, a narrow

[3] The association of the change from erosion to accretion south of Horsey with the inflection of the coast, which takes up a more southerly trend about the same place, should be compared with the similar changes in coastal direction and character which take place in Lincolnshire a little south of Ingoldmells Point (see page 156).—EDITOR.

shingle ridge fronting Benacre Broad was driven inland, and shingle and great slabs of marsh vegetation 15 ft. across were thrown into a wood at the southern margin of the marsh. At the point of the Ness itself, which now lies off Kessingland Level, there was little or no erosion. Further north, the sea-wall was damaged at Kessingland village where, in a few decades, the migrating Ness may offer a natural protection. The sea broke into Buss Creek north of Southwold and also flooded the marshes north of the river Blyth, converting the village into an island and damaging property on both sides of the river mouth.

Dunwich cliffs were undercut and bones from the old churchyard were strewn on the beach, but cliff recession was on the whole very slight. South of Thorpeness low dunes were overtopped by the sea at a number of points where footpaths used to cross them, and deltaic spreads of sand were laid down behind the gaps. The effects of the high sea-level and storm were much more spectacular immediately south of Aldeburgh where the shingle ridge which joins the great boomerang-shaped Orford Ness to the mainland was breached. Shingle was pushed over into the marshes and probably combed down into the sea as well. Tides flowed through the gap and across the marshes, and entered the Alde by breaches in the dykes alongside the river. It would be misleading to say that the Alde changed its course : its channel was hardly modified. Within three weeks bull-dozers had restored the shingle bank to something approaching its former condition, but the spit as a whole has made one more step inland. At the southern tip of the spit changes were not important and on the mainland opposite, at Shingle Street, shingle was driven inland partly burying some bungalows.

Physiographically the storm was immediately most effective on the low flat sections of the East Anglian coast ; only in a few places did the cliff-line retreat significantly. In most places sand and shingle were stripped from the beaches. In the case of shingle ridges backed by marshland, sand and shingle were swept over the crest to form lobes behind, and the ridges advanced inland as units. Where, on the other hand, beaches were backed by cliffs, even low cliffs or dunes, the retiring waters carried away more material than was thrown up by the breaking waves and clay or rock platforms were revealed. This is not an unusual outcome of the action of storm-waves, but in this case the waves were enabled to act at exceptionally high levels and comb down material from the uppermost parts of the beaches, and to strip the foreshore very completely as the tide receded. Cliffs were undercut, low cliffs retreated quite rapidly, and dunes were severely eroded. It appears that erosion on the high coasts will continue for some months as undercut cliffs collapse. The dominant process along the low coasts in the next few months is more likely to be one of accretion, as offshore bars which developed as a result of the storm move inshore. Some areas, at the end of March, had already gained more from the sea than they had lost by the storm.

Loss of life and damage to property were most severe along stretches of low coast where bungalows and other buildings have been constructed in recent decades in vulnerable positions at low levels close to the sea at such places as Hunstanton and Southwold. Older buildings which are mainly on higher ground were less seriously affected. Large areas of agricultural land were flooded (as can be seen from Fig. 1), and a proportion of this cannot be cropped for the next few years. Drains and ditches were silted up and in some places underground sources of water were polluted by sea-water. One of the main lessons to be learned from the sea flood is that low coastal forms are shifting features; they are hinged on to the cliffs and the cliffs are retreating; they partly depend on the cliffs for their supplies of sand and shingle and the supplies are held up by harbour works and local sea-defences. Furthermore, embankments constructed within the natural framework of shingle-ridge and sand-dune are in many places of great age; low-lying land once requiring only light defences may now require much more robust structures. The damage caused by the sea-flood can mainly be attributed to its exceptional nature, nevertheless it must be recognised that the task to which we are committed is one of attempting to maintain rigidly a boundary which is naturally flexible, and this task must become ever more difficult as the years pass.

V.—THE SEA FLOODS AROUND THE THAMES ESTUARY

A. H. W. Robinson

"OF late there has been such a tide as has overflown all meadows and marshes. All the Isles of Dogges, all Plumsted marsh, all Sheppey, Foulness in Essex and all the sea coast was quite drowned." Thus wrote the young Edward VI in January, 1552, describing the effect of an exceptionally high tide on the low-lying lands at the mouth of the Thames. No explanation was offered as to the cause of the abnormal rise of sea level and indeed none was forthcoming until 1800 when Graeme Spence, Head Maritime Surveyor to the Admiralty, noted in his "Account of the Tides between Shoeburyness and Clackton" that "the tides appear to be most of all affected by a sudden shift of wind from the southward to a strong gale in the north-west quarter which raises the tides to a very great and sometimes an alarming height, breaks down the sea walls and overflows and damages the lowlands; and sometimes causes two High Waters in the space of a few hours." This explanation of Spence as to the cause of what is now termed a storm surge, was amply confirmed by the events of November, 1897, and January of this year when extensive areas in Essex and north Kent were inundated by the sea.

Turning our attention first to the Essex coastland, it will be seen to consist of two distinct parts. In the north, from Harwich southwards as far as Clacton, the coastline, apart from one or two minor breaks, is formed of cliffs of London Clay which vary in height from 70 ft. near Frinton to less than 40 ft. in the vicinity of Clacton. These cliffs have been subject to constant denudation during the past centuries as a result of sub-aerial weathering and marine erosion. The rate of recession of the cliff face has varied considerably in different parts and over different periods of time: south of Walton a broad band 200–250 ft. in width was lost to the sea between 1874 and 1921, equivalent to an annual loss of 4–5 ft.[1]

To the southwest and south of Clacton, the London Clay is overlain by a variable thickness of alluvium in the marshlands of the St. Osyth area, those of the Dengie Peninsula between the rivers Blackwater and Crouch, and those of the "island province" of Foulness, Wallasea, Havengore, Potton, etc. The drained marshland areas all lie well below the high tide level of spring tides and are protected from periodic inundation by a clay sea-wall which along some of the more exposed stretches is faced with stone slabs. On the seaward side of the wall are the natural saltings colonised by *Spartina stricta*, *Salicornia*, *Glaux maritima*, etc. Reclamation of these areas has gone on for centuries, the estuarine silt being ideally suited for arable farming. Within the enclosed marshland of the Dengie Peninsula, there is an elongated sand and shell ridge rising about 5 ft. above the marshes on either side. Most of the farmsteads in the Burnham, Southminster, Dengie and Bradwell marshes are situated along the ridge.

The two distinct parts of the Essex coastline reacted in different ways to the storm surge. Along the cliff coast of the north, the abnormal rise of sea surface level (approximately 6 ft. at Holland Haven, north-east of Clacton) allowed the waves to break higher up the beach than is normal and undercut the base of the clay cliffs. Little reliable information is available relating to the height of the waves; an estimated difference of 8 ft. between trough and crest was observed by the sluice-keeper at Holland Haven. Small falls of clay from above resulted from this direct wave attack. Further slumping is likely to occur in an attempt to re-establish the natural profile of the clay cliff-face.

Along the protected coast of south Essex, the embankments were overtopped in many places by the vertical rise of sea level associated with the surge. The additive effect of the surge for the whole coast is not known, but at Holland Haven the tide gauge registered 15 ft. O.D. (Liverpool) at 00.45 hours on February 1st, while at Southend it reached 15·1 ft. O.D. (Newlyn). As many of the embankments have been raised only to 14 ft. O.D. the sea poured over these lower stretches and flooded vast areas of reclaimed land to a depth of from 1 to 12 ft (Fig. 1). Once formed, the gaps were widened by the head of water

[1] Erosion along this stretch is treated more fully in the author's "The Changing Coastline of Essex," *The Essex Naturalist*, 1953, vol. 29, part 2, pp. 79–93.

Fig. 1.—The major areas of flooding on the Essex and Kent coasts

and in many places the sea wall was completely demolished. In all about 280 breaches were made in the embankments along the Essex coast and river valleys. In a 5-mile stretch from Foulness Point towards Shoeburyness, one third of the entire length of the sea wall disappeared. On Canvey Island 40 breaches varying in width from 10 to 200 ft. were made in the sea defences. The northern part of the island known as Newlands suffered most, the embankment adjoining the South Benfleet creek giving way in many places as the water surged up the narrowing channel. In the same area the recently completed Coryton oil refinery was flooded after a break in the sea wall never previously breached.

An interesting change took place in the sand and shell ridge at

Sales Point near Bradwell, at the mouth of the River Blackwater, as a result of the storm. The bank rises about 5 ft. above the saltings and mud flats and prior to this year had the form of an elongated spit running approximately from south to north and recurving towards Sales Point (Fig. 2a). A gap existed between the distal end of the bank and the sea wall, the partially enclosed lagoon filling at every tide. During the period of the storm the form of the ridge changed completely. The gap at the distal end was closed and a new break-through made half a mile further south where one of the marsh creeks approached the ridge. Thus the former continuous bank of shell and

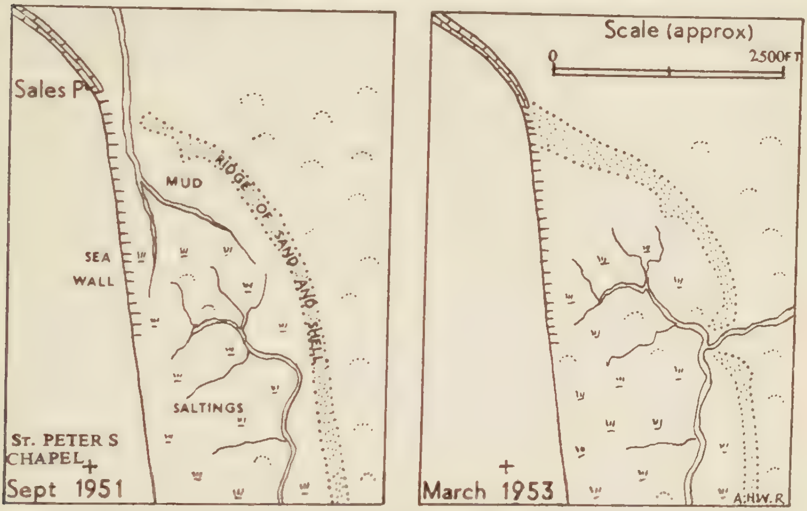

Fig. 2.—Sketch surveys of the changes in the sand and shell bank off Sales Point, Bradwell, Essex.

sand now has the appearance of two spits with opposed directions of growth (Fig. 2b.) It is possible that a similar development on a much larger scale might explain some of the so-called double spit features along the south coast of England, e.g., that at Mudeford at the entrance to Christchurch Harbour.

Within the flooded areas local elevations of a few feet stood out above the flood waters. On Foulness Island the higher ground near the church was barely submerged. In the Southminster marshes the sand and shell ridge remained uncovered in places and many of the farmsteads situated along it escaped serious flooding.

The coast of north Kent, with its marshes and intervening stretches of clay cliff, is in many respects similar to that of Essex on the other side of the estuary. Towards Reculver however, the Thanet Sands form the cliffs while in the Isle of Thanet they are built of Chalk. Another difference between the two coasts is of importance in assessing the effect of the surge in the two areas. Whereas the Essex coast is relatively sheltered from north and north-easterly gales, the Kent coast, trending east-west, is fully exposed to their fury.

As in Essex, extensive areas of protected marshland were flooded after the sea defences had been breached. Altogether about 78 square miles were inundated, the principal areas affected being in the Isle of Sheppey, the Faversham marshes and the Wantsum Channel. In the latter area, the sea wall between Reculver and Birchington was breached in many places and gaps up to 700 yds. in width allowed the sea to penetrate as far south as Sarre (Plate VII). The main road and railway into the Isle of Thanet were flooded, the railway foundations being so seriously undermined as to render the line unserviceable. There was also some flooding in the eastern arm of the former Wantsum sea channel near Sandwich as the river Stour overflowed its banks in a number of places. Throughout the Wantsum, the many isolated cattle mounds remained unsubmerged, a testimony to their usefulness in the past when the marshes were similarly flooded.

Due to its orientation, the north Kent coast suffered severely from direct wave attack and widespread structural damage occurred. The promenades at both Margate and Herne Bay and the newly constructed concrete sea wall at Minnis Bay were pounded and broken by the storm waves (cf. Plate VI). The 60 ft. high lighthouse at the end of the jetty at the entrance to Margate Harbour was undermined and toppled into the sea (Plate V).

Direct wave attack was also responsible for erosion of the cliff face in many areas. At Swalecliffe, between Herne Bay and Whitstable, the London Clay cliffs, 10 ft in height, were cut back 9 ft. Further to the east at Studd Hill where the cliffs rise to 50 ft., their lower parts were steepened and small falls, the prelude to more extensive slumping, resulted. At Beltinge, 1 mile to the east of Herne Bay the clay cliffs are more than 100 ft high and have been subject to continuous erosion in the past. On the night of February 3rd–4th, three days after the maximum development of the surge, an unusual cliff fall occurred. After storm waves had undermined the base of the cliff face the mass behind became unsupported and foundered. The cliff face moved bodily seaward, while a strip 60 yds. in width was let down about 40 ft. It was as though the waves had removed the buttresses of a cathedral nave leading to outward movement of the wall and collapse of the roof. The sunken area was about 220 yds. in length and presented the appearance of a cliff-sided gully running parallel to the coast.

To the west of the Twin Sisters Church at Reculver where the Thanet Sand cliffs have been gradually eaten back by the sea at the rate of about 1 ft. a year over the past 70 years, the high sea undermined the lower part of the cliff face and cut it back as much as 10 ft. in places. The heads of the groynes are now about 30 ft. from the cliff edge. The groynes themselves are accumulating little material and would appear to be of little use in coastal protection.

Observations made on both the Essex and north Kent coasts suggest that in many areas the beach profile was modified considerably by the storm. At Seasalter, west of Whitstable, for example, vast quantities of sand and shell were removed from the beach and carried

landward to be deposited in long isolated ridges at right angles to the general run of the coast. In appearance these ridges resemble the recurved ends of a composite spit. The exact magnitude of the change in the form of the beach in this and other areas is not easy to determine for levelling data relating to the pre-existing beach profile are seldom available. In Sandwich Bay, however, measurements of the changing form of the beach have been undertaken over a number of years by running levelling lines along eight sections at right angles to the coast. The latest set of data prior to the storm is for September, 1952. In Fig. 3 the beach profiles along one of the section lines before and after the storm are compared. It will be seen that the lower part of the beach formed of sand has been lowered by about 6 inches through-

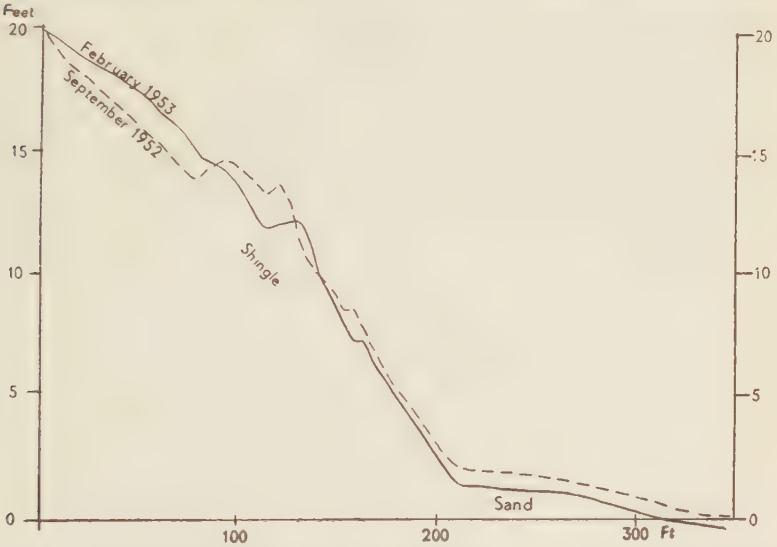

Fig. 3.—Comparison of beach profile for section line 1,000 ft. north of the Guilford Hotel, Sandwich Bay, Kent. Heights refer to Ordnance Datum (Liverpool). V.E. 13·5.

out, but has maintained its previous slope. On the upper beach there has been a considerable movement of shingle landwards. The marked break of slope which has always existed at the junction of the two deposits, was unaffected by the storm. These changes in the height of the beach are relatively small when compared with those which occurred in more exposed areas. It should be emphasised, however, that the changes noted above are greater in magnitude than any others which have been recorded during the past four years.

The amount of disturbance of the beach deposit would appear not only to be dependent on its character and size but also on its situation prior to the storm. At Swalecliffe where the shingle forms an extensive almost horizontal flat along the upper part of the beach, it was little affected by the storm waves. The plants of Sea Holly (*Eryngium maritimum*) which have colonised it also survived. Similarly, little

change took place in the almost horizontal spit of shingle of the Street at Whitstable.

Many other parts of the coastline bordering on the Thames Estuary were but little affected by the high tide and storm waves associated with the surge. From a study of these it may prove possible to assess the most effective methods of coastal protection to prevent a recurrence of flooding and erosion in other areas. For a cliff coast a concrete promenade with a concave face to break the force of the waves would seem to be effective in preventing undermining of the base of the cliffs. If the cliffs are formed of clay, the angle of slope of the face should be reduced to about 30° and drains inserted to minimise slumping which tends to occur following a drying out and subsequent wetting of the clay. Where this has been done, for example at Tankerton Slopes, east of Whitstable, the cliffs were unaffected by the storm. Along a marshland-fringed coast, the sea wall must remain the chief method of defence against inroads by the sea. But even if it is raised to such a height as to prevent an abnormal tide from surmounting it, there is always the danger of breaching by storm waves. For this reason a second sea wall, built some distance inland to localise flooding caused by the breaching of the outer wall, would appear to be most desirable.

VI.—A NOTE ON CANVEY ISLAND

D. R. Macgregor*

The destruction wrought by the February floods along the coast of England nowhere took so tragic a course as on Canvey Island where a settlement of some 11,000 people and covering 950 acres had grown up in a most vulnerable site.

A map of building development in the Southend area for the period 1905–1945 (Fig. 1) reveals some significant facts. The most striking of these is the great increase in building which utterly changed the appearance of much of the area, but it is more important to observe that the only extensive development on low ground was on Canvey Island. Vange, Pitsea and South Benfleet all grew securely along and above the 50-foot contour, but none of the buildings on Canvey Island stood above the 15 foot level and most were situated less than 10 feet above Ordnance Datum. The siting of long-established farming villages to the north east of Southend presents a marked contrast for in this area the old rural settlements show a careful selection of high and dry points ; in like manner the villages to

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Fig. 1.—Growth of settlement in the area of Canvey Island and Southend, 1905–1945.

the north and west of Canvey Island lay in 1905 in an arc around, but not on, the low flats and marshes ; only toward the eastern end of the island was there visible the embryo of the future settlement.

The Canvey Island disaster gives a stern warning of the risks involved in the development of settlements of any size close to sea level. In special cases it may be desirable to utilise such land for building, on economic grounds in respect of port development or the siting of industrial plants such as oil refineries (as at Grangemouth in Scotland), or for reasons of amenity as in the case of the resort of Skegness on the marshland coast of Lincolnshire ; in either case, if the ground floors of the buildings lie near or below high tide level, the need to provide protection should receive careful consideration. Canvey offers a special problem, however, for this large suburban community of recent growth with a population nearly equalling that of Skegness has neither the rateable value[1] nor the summer income of a seaside resort of comparable size.

If few people in the country at large have been aware of the changes which have taken place on Canvey marshes during the last thirty years, surely no one can fail to realise that adequate protective measures must be taken to safeguard the reviving settlement, disproportionate though the cost of such measures may be to the value of the property protected. It is especially important here that protection should not be sacrificed for economy, since Canvey is vulnerable to flooding from the tidal inlets to the north and west of the town as well as from the Thames itself. And in judging what is justifiable expenditure it is relevant to note that the population of Canvey increased by 96% in the period 1921–1931 and by 218% in the period 1931–1951, so that expenditure on the construction of adequate protective works would be made on behalf of a growing and not a static settlement.

[1] Skegness with a resident population very little larger than that of Canvey has a rateable value two-and-a-half times as large.

VII.—THE STORM FLOODS IN THE NETHERLANDS

W. E. Boerman*

The highest point of the Netherlands in the extreme south-eastern corner reaches about a thousand feet above sea-level. The low alluvial western and northern parts, about 40% of the country, would be submerged during normal high tides if dikes did not protect them against river and sea floods. Moreover, many former lakes and bays have been reclaimed by pumping out the water, and these dried-out lands (*droogmakerijen*) are situated very much below sea-level.[1] For instance: north-east of Rotterdam the ground is 19 feet below A.P. and in that part of the former Zuider Zee which was first reclaimed (i.e. in 1930) the deficiency reaches 23 feet. The physiographic[2] and historical[3] circumstances that have led to this state of affairs must be briefly recounted if the full significance of the disaster of February 1st to the Netherlands is to be properly understood.

During Tertiary times the areas that are now the Netherlands and southern North Sea were slowly subsiding under loads of mainly sandy sediment brought by rivers from the uplands to the south. Miocene and Pliocene lignite seams record phases when the region was swampy lowland and covered by vegetation which became buried by further sands and clays as the intermittent subsidence was renewed. Early in the Pleistocene period the great complex of delta fans was laid down by the rivers Ems, Rhine and Maas. Later, when the growth of the continental sheets caused sea-level to drop more and more, the rivers washed out valleys in these sediments. Rhine, Maas, Scheldt and Thames formed together one river system, which flowed across the North Sea plains to reach the sea north of the Dogger Bank. Ultimately the great Scandinavian ice sheet covered the northern part of these plains and dammed the river system. Together with the water of the rivers from the mountains of Central Europe, the thrusting fluvio-glacial waters found their way out by breaking through the chalky ridge between Dover and Calais. When the ice sheets melted at the end of the ice age the return of waters to the seas caused a rise of sea-level of about 200 feet and the southern part of the North Sea, the English Channel and the Straits of Dover were submerged from that time on.

Tides and tidal streams now came from the south as well as from the north. Consequently the earliest-formed coastlines and ranges of dunes were pushed backward and a range of younger sand-dunes was

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[1] Datum level at Amsterdam, designated A.P.

[2] G. J. A. Mulder. *Handboek der Geografie van Nederland*, Vol. 1, Ch. II, p. 222. Zwolle (N. V. Erven J.J.Tijl), 1949.

[3] G. J. A. Mulder. *op. cit.*, Ch. V, pt. I, p. 382, pt. III, p. 401.

formed, stretching from Calais to the firm Pleistocene cape of the isle of Texel, from where it curved eastward. Behind these sand-dunes the rivers filled up the lagoons with river silt and with bogs or fens. But again and again the continuous sinking of the land—probably about one and a half millimetres a year—caused further transgression of the sea. Particularly when spring tides coincided with the occurrence of strong continuous northwest stormwinds, the marine ingression could be disastrous. Then the waves were blown into the estuaries and creeks, overflowed the land and tore away the weak peat-areas. Disastrous consequences followed stormfloods during the 13th and 14th centuries, when the Dollart invaded the land in the northeast and the Zuider Zee swallowed the heart of the country. In the southwest, the "Saint Elisabeth flood" of 1421[4] was disastrous for the estuaries of Maas and Scheldt.

These regions have been inhabited since prehistoric times; originally only in the areas of higher Pleistocene sands, along the sand-dunes, on the naturally raised banks of river clay, and on the higher parts of tidal marshes. As a protection against riverfloods the houses on the river banks were sited on artificial mounds (the so-called *woerden* along the Maas and Waal). Similar artificial dry-points were created in the tidal marshes: in the province of Zeeland they are called *hillen*; in Friesland and Groningen *terpen*, *werden* or *wierden*.

It was about the 11th and 12th century that the offensive against the sea and river floods began. Dikes were built, creeks dammed up, rivers diverted. A great improvement was effected at the same time by the application of windmills, which made it possible to get rid of surplus land water. This was done in distinct organised regions; every draining-unit was called a "polder." When the whole land was occupied new polders were created by draining the lakes with the aid of the windmills (the so-called *droogmakerijen* = "drymakings"). In the 17th and 18th centuries this was often accomplished with the financial aid of the prosperous cities (e.g., the "drymakings" or polders called *Schermer* and *Beemster* in the province of Noord-Holland). This reclamation of land continued during the 19th century when steam power could be used for pumping (e.g., the *Haarlemmermeerpolder* and the *Prins Alexanderpolder*) and the technical developments of the 20th century have provided the tools to make huge dikes and to start the draining of the Zuider Zee. This former sea has been closed off from the North Sea by a dike 18 miles long, and two parts of it, with a total area of 280 square miles or 18,390 acres have already been transformed into polders. Reclamation is still going on, and the third Zuider Zee polder is now in construction. For several years past, voices have been heard in favour of closing some estuaries in the southwest of the Netherlands, and the former "Old-Maas" has in fact been closed by a dam near the city of Brielle[5]. This is possible because the artificially-excavated "New Rotterdam Waterway" provides a

[4] Referred to in the historical table on p. 144.
[5] See Fig. 1 on p. 184.

sufficient outlet for the water of the river as well as for seagoing traffic.

Navigation and drainage interests have always been more or less antagonistic. Dams, dikes and sluices can be built, but navigation needs locks. And near tidal waters this raises a further difficulty: every passage of ships through the locks enables a great quantity of salt water to enter the canals of the polderlands and to make the waters there more or less brackish. Locks as big as those of IJmuiden, at the entrance of the *Noordzeekanaal* (the Amsterdam-Ship Canal), can admit every time about 2,000 tons of salt! Particularly in the drier months of the summer season (about June) these salt difficulties are causing more and more trouble.

The dense population and intense economic activity in the western parts of the Netherlands require a good water supply. Drinking water is obtained partly from the sand-dunes, partly from the higher situated sandy outcrops and partly from the rivers. The fresh water reserve in the sand-dunes was always limited and even less now than it formerly was because so much is drawn to supply the cities of Amsterdam, Haarlem, Leiden and the Hague; the effect of this diminution can be seen in the vegetation of the dunes.

Under the upper silt and peat layers of the polderlands, which hold a rather thin layer of fresh water, the underlying formations contain salt water. This salt water was enclosed at the time when these marine sediments were laid down. The salt-water layer remains because the pumping which is necessary to keep the water-table below the level of the fields takes away the surface rain water: thus there is always a danger of the ditches becoming salty from below. So we have in the Netherlands a very complicated set of inter-related problems—land drainage; protection against river-floods and sea-floods; navigation by national and international river and canal traffic; the supply of fresh water for agriculture, horticulture and cattle rearing, as well as for industry and the continuously increasing population. An enormous freshwater reserve is required. The new freshwater IJssel-lake has met part of this requirement since it took the place of the ancient Zuider Zee, but still more freshwater reserves are needed. Estuaries must be closed, dikes made higher and river beds regularised. In the famous water-flow laboratory of Professor Thijsse at Delft, experimental investigations have been in progress for several years.[6] Possibly by the end of the present century inlets and estuaries will be closed by dams. But how numerous and how diverse are the difficulties! The western part of the Netherlands is sinking at a rate of over 0·04 inches annually (or 4–6 inches per century). Further, sea-level throughout the world seems to be rising as the result of increased melting of polar icecaps and glaciers. These changes call not merely for continuous upkeep of the outer defences, but regular building up as well. And the more since these dikes not only protect arable land, but also the

[6] J. T. Thijsse. De bodemdaling in Nederland en de peilschaal van Harlingen, *Tijdschrift van het Kon. Ned. Aardr. Genootschap*, 1931, p. 438.

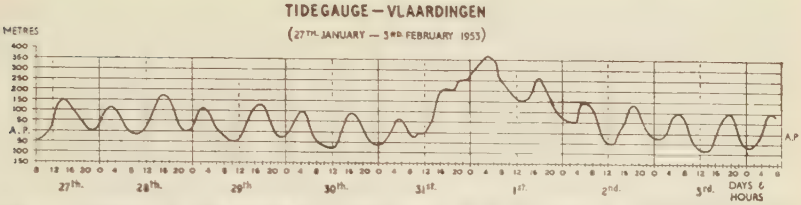

Fig. 1.—Record of tide gauge at Vlaardingen, 27th January–3rd February, 1953.

ever-growing and industrialised towns and villages with their precious buildings, machinery, etc.

A statistical investigation has revealed that about every 300 years an extra high stormflood can take place. The flood of February 1st, 1953, however, was about two to three feet higher than the result of the calculations. This risk cannot be accepted. So, dikes must be made still higher: this, however, is very expensive, especially for the mainly agricultural islands, where the total length of their protecting outer dikes is relatively great and the financial burden for the islanders relatively high. Many dikes are main roads of traffic. In many towns and villages the houses line the dikes on both sides, which makes heightening them almost impossible. The stormflood of January 31st and February 1st was extraordinarily high because the atmospheric depression which caused the storm surge was a very deep one with strong winds and because the conditions it created persisted for many hours over the southern North Sea and the Netherlands. The strong west winds in the night of the spring-tide hindered the water flowing back from the southern part of the North Sea and even totally prevented the tide ebbing from the southern estuaries of the Netherlands. A clear demonstration of the force of that night's gale is afforded by the fact that in the IJssel-lake near Amsterdam the water was driven away in easterly direction; consequently the entrance to the Oranje-sluizen, the port-locks, became nearly dry.

In the estuaries in the southwest a new high tide followed with the influx of about the same quantity of water from the sea as during the first high tide. This is very clearly revealed by the tide-gauge of Vlaardingen (Fig. 1). It is hardly to be imagined what the extent of the disaster would have been if the rivers had been in flood at the same time.

Disastrous stormfloods happened in the years 1825, 1894, 1906[7] and 1916.[8] After the stormflood of January 13th, 1916, P. H. Gallé computed the magnitude of the storm surge for each of the stormflood years at the several tide-gauges. His results showed that storm surges raised the water level about $2\frac{1}{2}$–3 metres (8–9 feet!) over the normal tides or even spring-tides. Of course, the duration and the direction, as well as the strength of the storms influence the magnitude

[7] A. A. Beekman. De vloed van 12 Maart 1906 in Zeeland, *Tijdschrift v. h. Kon. Ned Aardr. Genootschap*, 1906, p. 839. W. Cool. Overstromingen in Nederlan. *bid.*, 1907, p. 511.

[8] P. H. Gallé. De storm van 13–14 Januari 1916. *ibid.* 1916, p. 351. A. A. Beekman. De stormvloed van 13–14 Januari 1916. *ibid.* 1916, p. 364.

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of a storm surge. Also the depth is of some importance, because in deep water, undercurrents can more easily restore the disturbed balance of the water level.

The breaking of the dikes during the stormflood of February 1st, 1953, happened in different ways. Often it was the windblown waters, overrunning the crests of the dikes and consequently eroding the inner slopes, which were responsible for breaching. Backward erosion finally weakened the dike-crest and caused the further breakdown (Plate VIII). In other places the dike was not a homogeneous body of clay, especially when the dike had long been in use as a road and repeatedly made higher with loose materials. Then the dike-body became saturated with water and ultimately the inner slope (clay, grass, concrete or other stuff) was pressed off. Finally the outer slopes of the dikes sometimes were destroyed by heavy waves or undermined by powerful backstreaming undercurrents. Worst of all are those polders which have been submerged by salt water and where strong tidal-streams prevent quick repair[9]. When the lands are drained again, it takes a long time before all remnants of salt will be washed out of the soil. Also the structure of the soil suffers badly by the salt water. Fortunately this can be cured pretty well by means of gypsum. As to this treatment experience was acquired after the inundations in the province of Zeeland, caused by the German forces at the end of World War II[10]. During the first years after the flood, beans, peas and potatoes cannot yet be grown. A crop which can be cultivated on the newly flushed ground is spring-barley. All over the flooded areas the trees have suffered very much ; in the saltwater inundations all orchards and other trees were quite destroyed.

[9] Such conditions in Schouwen-Duiveland are referred to on p. 188.
[10] G. J. A. Mulder. *op. cit.*, Ch. V, pt. V, p. 522.

VIII.—THE NETHERLANDS FLOODS : SOME FURTHER ASPECTS AND CONSEQUENCES

K. C. Edwards

THE total area of the Netherlands flooded as the result of the storm surge of February 1st, 1953, amounted to some 400,000 acres, the parts worst affected being concentrated between Rotterdam and the Scheldt, involving the lands bordering the several estuaries and channels, together with the associated islands. A few less serious breaches occurred along the coast of North Holland while the farthest outlying districts to suffer ranged from Texel (Eendrachts Polder) in the north to points on the Belgian coast near Ostend in the south. The largest individual tract to be inundated was that round the confluence of the Waal and Maas spreading seawards on either side of the Hollandsch Diep (Fig. 1). This included the entire extent of the

Biesbosch, a large reed swamp still only partially reclaimed, itself the relic of a great storm in the early 15th century which converted the Diep into an arm of the sea. It was the highly productive and closely settled islands however which sustained the severest effects of both storm and flood. Devastation was particularly widespread in the cases of Rozenburg, Putten, Hoeksche-Waard[1], Goeree-Overflakkee, Schouwen-Duiveland, St. Philipsland and Tholen, and the situation remains serious, in July, in Schouwen-Duiveland, Overflakkee and part of South Beveland.

Apart from these agricultural areas, many towns were wholly or partially flooded. Along the New Waterway leading from the Hook of Holland to Rotterdam water surged into the fishing ports of Maassluis and Vlaardingen, then into Schiedam and the outer parts of Rotterdam itself. Much of Dordrecht was flooded including its ship-building yards and those at Alblasserdam. Parts of Flushing, at the entrance to the Western Scheldt, and Terneuzen on the south bank were also submerged. Damage to the embankments carrying the road and railway over the great bridges at Moerdijk arrested traffic on the main international route between Rotterdam, Brussels and Paris for several weeks. Except for these instances damage to manufacturing centres was slight and the industrial capacity of the country was not seriously affected. Locally along the exposed shores of the provinces of North and South Holland, as at Scheveningen and Noordwijk, gale destruction to sea-walls, coast roads and even buildings was severe.

Most of the inundations resulted from waves breaching the dikes and from the overtopping of the latter by the abnormal height of water impelled by the gale. On the other hand the dunes confronting the open sea along the western margins of both mainland and islands generally withstood the onslaught. Whether on the islands or along the estuaries, dikes yielded at numerous points, actually several hundred in all. Of nearly 700 miles of dikes around the stricken areas almost half the total length sustained some damage. Concerning the distribution of the breaches it is hardly possible to generalise and their quite irregular occurrence probably reflects the condition of the dikes rather than variations in wave height and ferocity of the sea attack. In some places wide gaps several hundred feet across were torn in the defences, while elsewhere the dikes eventually crumbled as the result of smaller multiple breaches. While the outer dikes proved so vulnerable, there were many instances in which inner dikes held, thus saving considerable areas from the tide. In this manner parts of the North and South Beveland, Tholen and eastern Walcheren were protected from flooding ; conversely the failure of the inner polder banks on Schouwen-Duiveland and Goeree-Overflakkee led to their almost complete submergence.

Naturally the larger breaches are the most difficult to close later, particularly in places where there is a shortage of clay. Nearly a

[1] This island is called Beijerland on some maps.

Fig. 1. Flooded areas in the southwest Netherlands, February 1st, 1953.

Fig. 2. Flooded areas in the southwest Netherlands, 1st July, 1953.

month after the disaster eight major gaps remained through which the tide ebbed and flowed freely; of these four remain open in July. One of these major gaps, at Willemstad on the south shore of the Hollandsch Diep, greatly delayed the efforts to drain the largest of the submerged areas, while most of the others are on Schouwen-Duiveland and South Beveland (Fig. 2). In many districts moreover operations have been hampered by the level of flood water being too low for salvage vessels to float and too high for excavators to move on the bottom. Incidentally the need to concentrate all available equipment for the task of sealing the major breaches has brought the Zuider Zee reclamation work in the north to a standstill.

Since the flooded polders lie at varying levels, they cannot be drained of their own accord but only by elaborate pumping arrangements. Not until the dikes have been finally closed therefore can the water be entirely removed and the work of restoration begin.

From the economic standpoint, especially as regards agriculture, the consequences of the disaster present a major national problem. The islands in particular, as a result of several centuries of elaborate drainage organisation, had reached a high degree of productivity by intensive farming which was noted for its diversity of crops[2]. The larger islands together supported a population of 412,000 of whom a majority were dependent on their farms, yet only Walcheren and the western half of Voorne-Putten escaped with less than 50 per cent. of their surface affected. In all, 332,500 acres of cultivated land were flooded, or 5·7 per cent. of the total cultivated area of the Netherlands. In the areas submerged the acreages under cereals (wheat alone

[2] *La Néerlandé ; études générales sur la géographie des Pays-Bas.* By various authors. International Geographic Congress, Amsterdam, 1938.

amounting to 80,000 acres), potatoes, leguminous crops and vegetables were all substantial but the devastation of land under flax and sugar beet was especially disastrous for the acreages under these industrial crops represented 22·7 per cent. and 24 per cent. of the respective national totals. It is here that the chief repercussion upon industry is likely to be felt, for a number of manufacturing units may be temporarily handicapped through failure of supplies.

Most of the flooded districts were important for dairying, while some were noted for their breeding herds. The loss of 25,000 head of cattle and over 15,000 pigs is therefore one of the most serious aspects of the catastrophe. Quite apart from the problem of restoring the pastures, several years must elapse before the quality of the herds can be re-established. (Other statistics relating to losses and damage are on page 187).

A few years ago the skilful restoration of Walcheren, following its deliberate flooding by the German forces in 1944, afforded many new lessons in reclamation, many of which are relevant to the situation created by the recent inundations. In Walcheren detailed soil surveys and the investigation of soil structure were of decisive value in reconstituting the farms and in determining what may well be desirable in the other islands, a reorganisation of holdings. On experimental fields much was learned concerning the degree of salt concentration tolerated by different crops. Sugar beet for example, the crop which from the standpoint of national production suffered most in the recent floods, proved, with barley, to be the most resistant to salt. Again, the restoration of salt-damaged soil was hastened by the application of calcium sulphate (gypsum) in amounts determined by the clay contents of each field. By this means crop yields in Walcheren have been made normal many years earlier than would otherwise have been possible.

The problems of grassland recovery differ from those affecting arable land. Provided the inundation is not of long duration—and it may be assumed that the areas recently submerged will not remain in such condition longer than in the case of Walcheren[3]—the retention of humus in the former grass cover renders the application of gypsum unnecessary. Instead a certain amount of chalk marl is required to alleviate lime deficiency. Further, at least on some of the islands, the necessity for livestock rehabilitation may provide an opportunity for the establishment of tubercular-free herds as was done in Walcheren[4].

With the primary task of re-draining completed, the Dutch will doubtless draw upon the experience of Walcheren and with their traditional determination and courage, apply their new techniques to the rebirth of the stricken provinces.

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[3] Walcheren was under salt water for 12 to 16 months; according to the Provinciale Waterstaat in Zeeland it is hoped to complete the draining of Schouwen-Duiveland by the end of 1953.

[4] A. Franke & C. Vissen. "Crops Grow on Walcheren Again." *World Crops*, Vol. 1. No. 1. London, Sept. 1949.

STATISTICS RELATING TO THE FLOODED AREAS IN THE SOUTH-WEST NETHERLANDS

Provided by the Netherlands Government Information Office, May 1st, 1953.

I—POPULATION. (Figures for Jan. 1st, 1952).

Region	Population	Area in sq. miles	Density per sq. mile
West Alblasserwaard	67,694	96	705
IJsselmonde (excluding Rotterdam) ..	57,285	39	1,469
Dordrecht Island..	78,308	23	3,404
Voorne-Putten and Rozenburg	31,170	88	354
H oeksche Waard (Beijerland)	40,711	104	391
Goeree-Overflakkee	33,922	87	390
West Brabant clay district & Biesbosch ..	122,120	257	475
Schouwen - Duiveland	23,881	85	281
Tholen and St. Philipsland	17,808	53	336
Noord-Beveland	7,365	31	238
Zuid-Beveland	60,098	137	439
Walcheren	74,665	79	945
Coastal district of Zeeuwsch-Flanders ..	49,134	152	323
TOTAL	664,161	1,231	540

II. FLOODED AREAS.

	Acres	Percentage of respective national totals
Total area flooded	400,500	4·6
Total cultivated area flooded	332,500	5·7
Arable land	205,000	8·9
including Wheat	80,000	6·1
Sugar beet	37,500	24·0
Potatoes	34,250	8·6
Onions	8,000	53·0
Flax	18,750	22·7
Leguminous crops	15,000	17·8
Meadowland	102,500	3·1
Horticultural land	25,000	9·4

III. LIVESTOCK LOSSES.

Cattle	25,000
Pigs	16,000
Sheep	2,500
Horses	1,500

IV. DAMAGE TO PROPERTY.

(Total number of houses and farms in stricken area : 143,567).

		Zeeland	Brabant	South Holland
Destroyed	Houses	1,210	395	1,721
	Farms	179	45	98
Heavily damaged	Houses	2,539	629	738
	Farms	378	161	160
Slightly damaged	Houses	8,717	6,776	22,981
	Farms	549	878	966

IX.—LETTER FROM ZEELAND

MARGUERITA OUGHTON

It is hard for us in England to realise how immense are the tasks that still confront the Dutch six months after the catastrophe. Our Assistant Secretary, Miss M. Oughton, has recently been engaged on relief work in Zeeland and in a letter from Schouwen-Duiveland, dated 20th June, she gives a picture that may surprise many of our readers.—Editor.

Roughly 70 per cent. of the total area of this island, she reports, is still under tidal water (see Fig. 2, p. 185). The dunes in the west are connected to the dry strip of polders north of Zieriksee only by the tenuous line of the northern sea dike between Scharendijk and Brouwershaven, some 2¾ miles. This dike, which carries the sole freshwater pipeline from the dunes to the drained polders, is faced to seaward with thick concrete slabs and tall wooden pillars, generally undamaged ; the road on its inner side, 15 feet below the dike top, is suffering erosion by daily tides, which in places submerge it at high tide and attack the soft grassy slopes which form the inner face of the dike. Until the completion of the repairs of the major breach (nearly 300 yards wide) at Schelphoek on the south coast, this immense flooded polder of 23,118 acres, chiefly pastureland, cannot be drained. Meantime the flood water will continue to erode the inner faces of the dikes in which holes are undercut especially by the flowing tide ; the northern road is being undermined ; and the less substantial farms and buildings are gradually being demolished, while everywhere mud and sand are being deposited on the former land surface. Subsidiary repair work endeavours to check further erosion of the inner dikes that separate the flooded area from the drained neighbouring polders, and of the remaining dike link between west and east. Sand raised by dredgers lying off the north coast is in places pumped through long pipelines to form a protection for the road at the dike foot (cf. plate IX).

In the eastern part of the island (Duiveland) a group of flooded polders still separates the most easterly polder, which was drained by May 1st, from the dry central area. Through gaps in both the north and south coasts tidal currents stream right across the polders of Oosterland and Sirjansland. On the landward side of these gaps submarine channels, 45 feet deep[1], are being scoured in the polder surfaces, making repair work more difficult ; these channels will substantially alter the topography locally when the area is ultimately drained. Other changes on the map are probable in field boundaries, following the consolidation of land holdings when restoration begins . . . The villages, with their characteristic 17th century stepped gables, are commonly ring-villages standing on shallow mounds, and only their centres are dry. Many of the buildings on the

[1] The maximum depth at the Schelphoek gap is reported to be 37 metres (information from Provinciale Waterstaat in Zeeland).

outer side of the ring have been shattered by the impact of the first floods ; inside the houses the furniture and other "movables" are shuffled daily by the tide, while mud and sand are deposited regularly on floors and pavements.

Repair work on the gaps in the sea dikes is being carried on with great urgency in an effort to close the breaches before the autumn tides. The repair dikes seem usually to be built in a semi-circle inside the gap (plate IX), sometimes outside it, utilising a sandbank offshore. The ends of the very large repair dike at Schelphoek will meet the existing sea dike some 150 yards away from the ends of the gap, through which strong currents at present surge ; later secondary "radial" dikes will probably be extended towards the gap itself to facilitate the rebuilding of the original dike. Along the waterway of the East Scheldt come barges carrying boulders, rubble, clay and great faggots of willows : these last are used to form "mattresses" for boulders at the very base of the dikes or as "binding" between layers of stones and rubble in their upper parts.

The trees around the church in the centre of the ring-village of Dreischor, whose polder was "wet" for about two months, are now in full leaf, but the brownish, curled look of the leaves is a record of the salt water underground. The surrounding fields, about 2,743 acres, lie like a grey waste covered with caked and cracked mud, and scattered with decayed sugarbeets and potatoes, washed from their clamps, and bundles of flax. Weeds and grass struggle through the crust, but no crops survive. Great lumps of peat, eroded by the plunge of the early floods, over the inner dike, from a depth of over 15 feet from below the polder cover of silt and clay, are now deposited several hundreds of yards away near the edge of the village. Ploughing will not take place until next year ; meantime prefabricated wooden houses must be constructed, damaged buildings repaired and farm machinery overhauled. There remains the lengthy task of cleaning and re-digging the deep ditches that surround every field, and in which much of the flotsam of the floodwaters was eventually deposited as the polder was pumped dry. The most striking feature of this desolate farm scene is the almost total absence of livestock—the arrival of the first crate of pullets was an event in the village—and for some time to come the somewhat desultory supply of fresh water from the dunes, along that threatened northern sea dike, will be eked out only by "imported" pasteurised milk.

GEOGRAPHICAL ASSOCIATION

Spring Conference, Lincoln, April 7th–11th

The Spring Conference held at Lincoln will be remembered as one of the very best we have known. It was attended by about 200 members and was superbly well organised by the local committee. Lectures on the physical and human geography of the region were given by Professor D. L. Linton and Professor K. C. Edwards, who were ably supported by other members of the staff of the Department of Geography at Nottingham University in a first class series of field excursions to the Lincolnshire coast, Humber region, Trent valley, Lincolnshire Wolds and the Fenland. There were visits to contrasting types of farms and to local industries. We are also deeply indebted to Dr. J. F. W. Hill and Mr. R. L. Stirling for the valuable contributions they made, in lectures and discussions on problems concerned with the historical geography of Lincoln and local regional planning needs. Their specialist knowledge in fields of study cognate to our own was indeed stimulating to a gathering of teachers of geography. We were honoured by a reception by the Lord Mayor and Lady Mayoress and the Sherriff of Lincoln, and were pleased to welcome them, together with many other civic and ecclesiastical dignitaries at a formal Conference Dinner. The meetings concluded on Friday evening with an enjoyable social gathering of a less formal character.

To the Governors of the Diocesan Training College, Lincoln, a special word of thanks is due for allowing us to use the spacious residential facilities at the Constance Stewart Hall. For the indefatigable local Branch officers, Mr. James Bell, Miss Margaret Goodrich, Miss Rhodes-Denton and the Branch President, Professor Edwards, no praise can be too high. To them especially warm thanks are extended.

Diamond Jubilee Celebratons

The Association will mark its Diamond Jubilee by a meeting, to be held in Sheffield, on Saturday, September 26th, 1953, of members and friends. Enclosed with this issue is a leaflet giving the programme of the meeting. Members are urged to complete and return it to headquarters office as soon as possible. We hope that there will be a really large attendance to celebrate this occasion.

Annual Conference, 1954

The Annual Conference will be held in London at the London School of Economics from December 30th, 1953, to January 2nd, 1954. The programme will be circulated with the November issue of *Geography*.

Summer Meetings, 1954

It is with regret that we have to announce the postponement until 1955 of the proposed Summer School to be held in Brittany under the leadership of Professor E. G. Bowen. This step has been necessitated by commitments abroad of both British and French geographers concerned with the organisation of the course. An announcement about the School will be made in *Geography* during 1954.

Arrangements are being made to hold the Second International Conference of Teachers of Geography at Hilversum, Netherlands, between August 22nd and 29th, 1954. Members will recall that the First Conference was held at Sheffield in 1951. Fuller information about the meetings will be published in *Geography* in November. We should be glad to hear at headquarters office from members who would be interested to attend this Conference.

We are also exploring the possibilities of arranging a field study course on the Continent during the summer of 1954, probably to precede or to follow the International Conference in the Netherlands. Some indications of members' needs, both in the type of course and in its location, would be helpful in furthering these plans.

New Section for Further Education in Geography

The new Section for Further Education in Geography (Technical Colleges, Polytechnics, Institutes and Colleges of Further Education, Day Continuation Classes, etc.), has been formed, with Mr. W. Wallace as Chairman and Mr. G. Lighton as Secretary. Any member interested in the work of this section should write to Mr. Lighton, Walford, Park Avenue, Ashton-on-Ribble, Preston. The problems of teachers of geography in Secondary Technical Schools are still dealt with by the Secondary Schools Section.

Anthology of Geographical Literature

We should be very glad to receive at headquarters notice of any descriptive extracts which teachers of geography have found to be of value in class-work on any world regions or on any branch of our subject. Work is now proceeding on the preparation of such extracts for publication as anthologies, and it is felt that many members may have valuable suggestions to offer which it may be possible to incorporate in the selections made. Any such suggestions should be sent to the Assistant Secretary at headquarters office as soon as possible, and preferably before August 31st.

Chair of Geography at Glasgow

We extend cordial congratulations to Dr. Ronald Miller, of the Department of Geography in the University of Edinburgh, on his appointment to the chair of geography at Glasgow in succession to Professor A. Stevens who retires at the end of the 1952–53 session.

Netherlands Information Service

The Netherlands Government Information Office has agreed to the supply of information and to the loan of publications to members of the Geographical Association, on application through headquarters library. It is hoped by this arrangement to assist members to obtain information published on the Netherlands or by Dutch writers generally, either in English or Dutch, that is not normally available in this country. Enquiries for information should be as specific as possible to obtain speedy and satisfactory attention; authors, publishers and dates of publication should be quoted where known.

REVIEWS OF BOOKS.

With very rare exceptions, books reviewed in this journal may be borrowed from the Library by full members or student library members of the Association.

Climate and the British Scene. (The New Naturalist Series.) Gordon Manley. 15 × 22 cm. xviii + 314 pp. London. Collins. 1952. 25/–.

To the geographer this is one of the most interesting volumes in this series. After a clear explanation of the causation of British weather, Professor Manley describes the weather, both normal and abnormal, of each season with a sensitive perception of its impact on our feelings, emotions and daily activities. There follow some chapters on mountains, moorlands and snow and the book ends with an examination of the range of variability of British climates. Aesthetic appreciation of weather conditions is aided by some superb black-and-white photographs, but the coloured plates are less consistently good. Some are extremely effective, others are gaudy or just unfaithful to nature, and, as so often happens when they have to be spaced evenly through the book, many are far away from and unrelated to their context. A.A.M.

The Climatological Atlas of the British Isles. Air Ministry, Meteorological Office. 25 × 31·5 cm. iv + 139 pp. London. H.M.S.O. 1952. 52/6.

This new publication of the Meteorological Office may reasonably claim to be the first complete climatological atlas of the British Isles to be published. Although maps and charts have from time to time appeared in the *Rainfall Atlas of the British Isles*, in *Averages of Humidity for the British Isles* and in the *Book of Normals* they have never previously been collected in one publication. The new atlas is comprehensive and covers pressure, wind, temperature, rainfall, snow, thunder, humidity, sunshine, visibility with fog, and cloud in ten sections. The averages and means have been derived for the major part from statistics for the first thirty years of the present century (the standard period selected by the International Meteorological Organisation) and are presented either by months or years in a series of over 200 maps. But climate is not to be gleaned

completely from averages and this fact is recognised by the carefully selected maps showing extremes of certain fundamental elements which have been experienced from time to time.

Each of the ten sections is supported by an explanatory text in which the collection and cartographic representation of the data has been carefully explained: tables of certain elements and bibliographies are also included. A detailed orographical map precedes the climatological maps and the whole publication is exceptionally well produced. It is a work which most certainly must be added to any library where geography is studied at advanced school, college or university level: and it will clearly be of considerable value to planners and a great variety of governmental agencies. W.G.V.B.

The Sea Coast. (The New Naturalist Series.) J. A. Steers. 15 × 22·25 cm. xii + 276 pp. London. Collins, Ltd. 1953. 25/–.

This latest book by Professor Steers is in no sense a simplified version of his earlier work *The Coastline of England and Wales* (1946). Not only does it contain much additional material, partly the result of research on various aspects of coastal evolution published in the last few years, but there is also the first detailed account, in book form, of the coast of Scotland and the adjacent islands. In addition, coastal evolution is related to the broader aspect of the origin of the British Isles themselves, a subject neglected since Sir Halford Mackinder interested himself in the fundamentals of the problem over 50 years ago.

As in the other volumes of the New Naturalist series, the photographic illustrations have been well chosen and are most effective, particularly those in colour by the author and the many oblique air-photos of J. K. St. Joseph. The book is also well illustrated with maps but it is unfortunate that some of these have been over-reduced in the preparation of the blocks, rendering the lettering difficult to read (Figs. 19, 25, 27, 35, 40). There are some minor errors in spelling in both the text and maps (Fig. 47). These, along with Fig. 22, inserted upside down and the misplaced captions to some of the colour plates, can easily be corrected in a subsequent edition. More difficult to overcome at this stage is the inconvenience caused by inserting double page figures far from the text to which they refer. It is disconcerting when reading about the Broads to be confronted with a geological map of the South Gower peninsula. As is stated in the Preface this has been done to facilitate printing on to a single sheet of paper, but a more satisfactory solution might have been found e.g. by using a folding sheet. These minor points of arrangement, however, do little to detract from the great value of a book which fully succeeds in its objects, namely, to give a comprehensive account of the sea coast of Great Britain and to call attention to the need for further study of its many unsolved problems. A.H.W.R.

Census of Woodlands 1947–1949. Woodlands of Five Acres and Over. Forestry Commission, Census Report No. 1. 15 × 24 cm. 264 pp. London. H.M.S.O. 1952. 12/6.

This, the most comprehensive report based on the recent Census of Woodlands, has a specialist appeal in content although there is much of wider interest. The detailed accounts of survey procedure may assist in the development of geographical technique. A thorough review of the status of British woodland has been long overdue and this report with its nineteen distribution maps and photographic inset showing characteristic examples of forest types also supplements the Land Utilisation Survey.

Timber from hedgerows and plots of less than five acres has a greater scenic than economic value and is to be considered separately. The inevitable changes since the Census was completed cannot detract from the worth of the Report but the repercussions of the war, the high proportion of woodland economically ineffective and the low average annual increments in timber volume clearly reflect the neglect of the past and the effort needed now and in the future.

R.C.

The Heritage of Early Britain. M. P. Charlesworth, and others. 12·5 × 19 cm. 196 pp. + 24 plates. London. G. Bell & Co., Ltd. 1952. 12/–.

Well-known Cambridge scholars have co-operated to publish this series of lectures in a book dedicated to the memory of Charlesworth who organised the scheme. G. E. Daniel on prehistoric peoples, J. G. D. Clark on the livelihood of early folk, and J. M. de Narvarro on, mainly, Celtic Art, between them cover the

pre-Roman period. Charlesworth's own lecture on the Roman occupation is, in the main, condensed from his attractive little book on *The Lost Province*. Nora Chadwick contributes a vividly attractive chapter on the Celtic West. This is followed by a survey of England in Anglo-Saxon and Danish times, a survey which is rather too conventional. The Norman chapter attempts a fair judgment and M. D. Knowles gives a useful summing up. But the chapters after Mrs. Chadwick's are practically all on England rather than Britain, which is a pity, because with Britain for subject as well as title there would have been more freshness. H.J.F.

English Local History Handlist. 14 × 21·5 cm. 74 pp. London. Historical Association. 1952. 2/6.

We are very glad to call attention to this very useful publication of our sister association. It is a second edition of the handlist and is considerably enlarged, not only by additions to the several sections, but by the addition of new sections. It seems to be remarkably free from errors. The only one we have noted is that W. B. Wright is given on page 7 as E. B. Wright and on page 10 as W. R. Wright. Those interested in local studies will find useful material. More specific geographical references will be found in Section I—Topography, which includes Geology and Physical Features, Ecology and Geochronology, Climatic Influences, Historical Geography, Maps and so on. There are useful references, also, in the sections on Prehistoric Archaeology, Trade, Roads, Warfare, Ports, Agriculture and Place-Names.

Guide to the Berkshire Record Office. Prepared for the County Records Committee by Felix Hull. 13 × 20·25 cm. xv + 117 pp. Reading. Berkshire County Council. 1952. 4/–.

This guide lists archives relating to Berkshire deposited in the Record Office and also indicates the whereabouts of other Berkshire archives. It represents a noteworthy effort to preserve public records relating to the county and to make them accessible to the student. It is illustrated by a number of facsimiles of deeds and other documents.

A Handbook of Local History: Dorset. R. Douch. 14 × 21·75 cm. 143 pp. Bristol. University of Bristol. 1952. 3/–.

This appears to be a pioneer effort. The preface states that "this Handbook has been compiled in the hope that it may furnish students who are interested in the history of Dorset . . . with ready references to printed materials . . . It is essentially a Handbook supplying details of illustrative local material and suggesting lines of enquiry; it is not intended to be a complete bibliography." The aim is admirable and appears to be attained. T.C.W.

The Domesday Geography of Eastern England. H. C. Darby. 16 × 23·5 cm. xiv + 400 pp. London. Cambridge University Press, Ltd. 1952. 55/–.

The Domesday Geography of Eastern England is the first of a set of six volumes which will cover, region by region, the whole Domesday Survey, the sixth volume giving the final picture of England as it emerges when the studies are placed side by side. The essence of Professor Darby's method is to map in uniform style and scale all the separate items of information, settlements, population, ploughlands, meadow, waste, and so on, which can be compiled from the Survey, first of all for each county. The county maps are then combined into regions, and these will be again combined into the whole country surveyed. This first volume, for example, includes over a hundred maps, which show clearly not only the diversities of geography within the six Eastern Counties, but also the diversities of procedure and nomenclature employed by the Clerks of the Survey, some of which involve apparently insuperable difficulties of interpretation. Professor Darby has been publishing papers on separate aspects of his theme over a period of nearly twenty years, and with this experience behind him he is meticulous in his resolve not to minimise difficulties or draw conclusions beyond the available evidence. The same cautious attitude is imposed on the collaborators who will handle succeeding volumes under his editorship, and the result should thus provide geographers, historians, and economists alike with a firm, factual picture which should stimulate new specialist studies, and from which, almost certainly, new conclusions will spontaneously emerge. The maps are beautifully executed, some using colour, and the symbols are quantitative wherever possible.

An appendix briefly summarises the information, and we learn for example that the free peasantry in this Region comprised over one-third of the total enumerated rural population (over a half in Lincolnshire) while serfs were nowhere more than 13 per cent. (in Essex), the most numerous element on the whole being villeins, bordars and cottars. That churches are mentioned in 247 places in Lincolnshire but in only three places in Cambridgeshire, exemplifies the variability of the record, and adds emphasis to Professor Darby's closing words : " In giving us something the Domesday Book has withheld much." E.G.R.T.

The Weald. (The New Naturalist Series). S. W. Wooldridge and F. Goldring. 15·25 × 22·25 cm. x + 276 pp. London. Collins. 1953. 25/–.

The public served by the New Naturalist Series includes others than geographers, and this has imposed upon the authors the necessity of giving a rather more extended explanation of geographical processes than is normally met with in a regional study. This is not for one moment to suggest that the explanations are so extended as to be unwelcome, but rather that the book is more than a simple regional study : for the geographer it is a pleasant blend of systematic and regional geography (spiced with frankly expressed opinions on the relationship between field and laboratory sciences) : for the non-geographer it offers geography at its best and must inevitably assist in raising the status of the subject.

The geology, denudation chronology and hydrology are described in turn, then vegetation and soils, and finally human settlement and development of the region. An intimate knowledge of the Weald is shown and a sincere love for this lovely corner of England. British geography has as yet produced little to compare with the regional series of the French ; but this work might well stand as the prototype of such a series.

Most of the beautiful photographs clearly illustrate points in the text. The maps and diagrams are good, but a large scale map would have been of great assistance to the reader. E.M.Y.

The Broads. (The Regional Series). R. H. Mottram. 14 × 21·75 cm. viii + 254 pp. London. Robert Hale, Ltd. 1953. 18/–.

" . . . so large and striking a portion of our national stock of beauty and interest, fresh air and sport as they provide must have a literature, and I have tried to indicate where it is to be found rather than to provide a substitute for it." This quotation (p. 235) strikes the key-note of this book ; for its distinguished author, at the risk of a certain lack of coherence, relies very largely on extracts from a wide variety of sources. The geographer will find nothing of value, and much that is misleading, on the physical origin of the Broads ; but the book gives a splendid insight into the history, literature and rich native stock of the region. There is a beautifully written contribution on wild life by E. A. Ellis ; and the book concludes with a shrewd discussion of " the future of the Broads : National Park, private reserve, or commercial exploitation ? "

B.H.F.

Oxfordshire. (County Books). J. Cannan. 14 × 23·5 cm. xii + 275 pp. London. Robert Hale, Ltd. 1952. 18/–.

Oxfordshire has been fortunate in its author. Miss Cannan manages to impart much useful and detailed information in an interesting and stimulating manner. To distil the history of 21 colleges and a number of other institutions into 70 readable pages is a feat in itself. She faces and overcomes the problem of dealing fairly in one book with both Oxford and Oxfordshire. While the city and university receive their full share of attention, the reader retains the conviction also that the market towns, villages, houses and countryside of the county have much to offer. The book is illustrated with a series of excellent photographs, mostly architectural, but with a map that is not worth the paper on which it is printed. A.F.M.

Lincolnshire. (The County Book Series). J. Bygott. 14 × 22 cm. xii + 281 pp. London. Robert Hale Ltd. 1952. 18/–.

This volume contains a good deal of valuable and interesting information on Lincolnshire but in other respects, whether judged as the work of an experienced geography teacher or of a writer having a life-long acquaintance with his county, it is frankly disappointing. The treatment of the various aspects of Lincolnshire

is regrettably unbalanced and too often there is a lack of discrimination between the important and the trivial. The author's style moreover, quite apart from persistent infelicities, varies disconcertingly from one section to another, suggesting too close a dependence on the source books, as indeed is obvious in the formal account of the geology.

The geographer and, it is hoped, the general reader for whom the book is mainly intended, will appreciate the fact that the earlier descriptive chapters represent a true regional approach based on the broad physical subdivisions of the county. Elsewhere much of the subject matter is poorly organised. Examples are the ill-proportioned chapter on industries and the scattered, incidental treatment of the settlement pattern, particularly as regards villages, which *in toto* amounts to considerably more than is included in the section devoted to that topic. The author however succeeds in conveying to the reader much of the distinctiveness of the different parts of this extensive county. Besides the intimate glimpses of a richly varied countryside and the innumerable half-forgotten details of the life and customs of Lincolnshire people, there is a great wealth of factual items which, if the volume were more fully indexed, would make it, in addition to fulfilling its main purpose, a useful reference work. It is appropriate to mention that among the references to notable men whom the county has nurtured, is a tribute to Sir Halford Mackinder who was born at Gainsborough.

The book is illustrated by excellent photographs ; there is a selected bibliography (with some significant omissions) and a map at the end which, though reasonably clear, fails, as so often in this kind of publication, in the important matter of depicting the relief satisfactorily. K.C.E.

The Forest of Dean. (The Regional Series). F. W. Baty. 14 × 22 cm. vii + 240 pp. London. Robert Hale, Ltd. 1952. 18/–.

Mr. Baty warns the reader that his book is not intended to be a guide or an expert treatise, so much as a personal word-picture largely executed on the site. Thus he writes delightfully of a countryside with which he is intimately acquainted, and with such fervour that he can successfully ignore the convention which usually places the necessary accounts of geological and geographical background in the first part of such a book.

The purely descriptive chapters are the best, especially the one devoted to wild life. Elsewhere, in delving into prehistory, for example, there is what is probably untenable conviction as to the origins of the people, but strange reluctance to discuss the history of the iron industry. There are 25 attractive photographs. One wishes that the one inadequate map had been supplemented by others of more orthodox technique. F.T.B.

The Trowbridge Woollen Industry. Wiltshire Archæological and Natural History Society. Records Branch, Vol. VI. Ed. R. P. Beckinsale. 16 × 25 cm. xxxvi + 249 pp. Devizes. 1951. 25/–.

Andrews' and Dury's Map of Wiltshire 1773. Wiltshire Archæological and Natural History Society. Records Branch, Vol VIII. 22 × 28·75 cm. 38 pp. of Maps, 2 pp. of Text. Devizes. 1952. 25/–.

(Both obtainable from Mr. M. G. Rathbone, 4 Beechen Cliff Rd., Bath.)

The Records Branch of the Wiltshire Archæological and Natural History Society has recently issued these two volumes (also available to non-members) which though undoubtedly of particular interest to the county specialist have also a more universal appeal. Both works relate to the earlier part of that period when the English landscape was in process of being transformed by revolutionary changes in the technique of agriculture and industry, whilst new and more accurate methods were being employed to make detailed surveys of some counties. Such a survey was that undertaken for Wiltshire by John Andrews and Andrew Dury. Their map, drawn originally on a scale of approx. 2 inches to the mile, has now been successfully and pleasingly reduced to about half that scale, the 18 sheets and index map being preceded by a useful introduction. Settlement, roads and earthworks figure prominently. Boundaries of the hundreds are superimposed in colour, but relief is shown by the rather unsatisfactory vertical shading then prevalent. Reproductions like this of the work of some of our lesser known cartographers will always be welcomed.

The transcription, in part abridged, of the annual accounts and stock-takings from 1804–24 of the still active Trowbridge firm of J. and T. Clark forms the greater part of Vol. VI. Several ' gentlemen clothiers ' had found in the town

a convenient location for the organisation of the cloth-making industry but technological advances and changes in organisation at the end of the 18th century resulted in the disappearance of many businesses: others, as was the case with Clarks', became reorganised as 'manufacturers' and it is the records subsequent to this reorganisation which are here edited.

Dr. Beckinsale, author of a forthcoming work on the West of England Textile Industries, has included a valuable introduction summarising such major aspects of the local woollen industry as raw materials used, manufacturing processes, water supply and power, finished products (which in this case were wool-dyed narrow cloths rather than broadcloths), markets, transport, etc. I.E.J.

Bellingham and Wark: Population Structure and Employment Conditions. 56 pp. **Migration and Employment Among School Children and Young Adults. 1931-1950.** 56 pp. **A Comparative Survey.** 95 pp. 17 × 24·5 cm. J. W. House. Newcastle-upon-Tyne. North Tyne Survey Committee. 1952. n.p.

These pamphlets are parts of a current research series designed to present some of the social implications of the Forestry Commission's ambitious project in the North Tyne valley and Redesdale.

The first covers the past movement of population, and the reasons for it, in Bellingham R.D., the present distribution and present and future opportunities for employment. In the second, there is a detailed analysis of the total present migration amongst school children and school leavers, *i.e.*, families with young children who are the source of nourishment to the labour force of the future. The third gives a sympathetic analysis based on a door-to-door enquiry, which might act as a model, of the migration histories within 90 per cent. of the families in Bellingham and Wark.

The object of the study as a whole is to investigate the possible reactions between the Forestry Commission's future labour needs in an extensive and isolated district and the re-establishment of the stable, because balanced, small rural society, as advocated in some of the papers presented to the meeting of the British Association at Edinburgh in 1951. Population density and distribution are important features from the viewpoint of social structure. The large-scale development of forestry in the area will bring about the most far-reaching changes in its long history. Present employment in forestry is 400 to 450, but ultimately it is expected to reach 2,000 or 3,000; thus, with their dependents, the population will be quadrupled. As this will result largely from immigration, the planting of this "New Forest" will involve the creation of inhabited places, not, as in the time of William I, their destruction. Hence the scope of this objectively factual study has a much greater geographical bearing than the individual titles would suggest. It would be helpful if these and future publications could be allocated serial numbers for the purpose of cross-reference. L.R.L.

The Little Hill Farm. W. B. Crump. 13·75 × 21·5 cm. 77 pp. London. The Scrivener Press. 1952. 6/–.

This concise, well-illustrated book is about the settlements and farming of the higher slopes and tributary "denes" of the Calder Valley in the West Riding. It is commended as a very suggestive local study of change within "marginal land." A farming population of high density arose on land having unfavourable physical conditions but adjoining an expanding industrial region. The author shows how the little farms were carved out as "royds" (clearings) in the waste, and how in a century the rate of decline has accelerated, the final enemy being the water-engineer. He gives details of shape and function of buildings and implements, adapted to local conditions, and of the old way of life. F.J.C.

Scientific Survey of South-Eastern Scotland. British Association for the Advancement of Science. 18·5 × 25·5 cm. 208 pp. Edinburgh. Local Executive Committee of the British Association for the Advancement of Science. 1951.

Belfast and its Regional Setting—a Scientific Survey. British Association for the Advancement of Science. 18·5 × 24·5 cm. 211 pp. Belfast. Local Executive Committee of the British Association for the Advancement of Science. 1952.

The annual meeting of the British Association for the Advancement of Science is an important occasion for the city in which the meeting is held, and to help

members appreciate the region within which the excursions are made each is provided with a comprehensive scientific survey. The two handbooks here noticed will long outlive the particular occasions for which they were written. In them are brought together the fruits of many scholars in the description and analysis of two areas of considerable geographical interest. When the general standard is so uniformly high it would be invidious to attempt to select particular essays for special mention but it seems desirable to draw the attention of geographers to items that are obviously of direct interest to them. Such sections in the survey of South-Eastern Scotland are "The Region and its Parts," "Weather and Climate," "Agriculture," "Mining," "Manufacturing Industries," "Changes in Rural Life and Landscape" and "Population." Similarly in the Survey of Belfast and its region there is an admirable essay on "The Region and Its Parts" and well-written sections on the economic history, agriculture, industries, land use and settlement of Ulster. N.P.

The Cuillin of Skye. B. H. Humble. 18·5 × 25 cm. xv + 144 pp. London. Robert Hale, Ltd. 1952. 30/–.

Mountaineering is surely the most delectable of all the branches of geography, far excelling Arctic exploration in its wide variety of terrain, whilst still retaining the spice of difficulty and danger, and the satisfying test of body and spirit. The Cuillin—architectural if not structural Atlantic outposts of the Alps—are our youngest mountains, but their Tertiary gabbros are not surpassed by any more ancient rock of the mainland. Herein is the history of their exploration—not dry and dusty as some histories are, but lively as the air of the mountains and warm-blooded as the personality of the author. Mr. Humble derives the name from Old Norse, *kjoll*, the keel of a boat or a ridge, topographically accurate and in keeping with the strong Viking influence in this district. The one complaint against a book so admirably illustrated concerns the maps. The peaks are numbered but the references unfortunately appear on the back of the principal map, while a useful solid drawing on the endpapers has no mountain names whatever. The O.S. sheet has never been very popular, most mountaineers preferring the 3 inch to the mile photographic triangulation map with form lines, prepared for the Scottish Mountaineering Club Guide-book but published also separately. R.M.M.

The Highlands of Scotland. (County Books). Seton Gordon. 14 × 22 cm. x + 328 pp. London. Robert Hale, Ltd. 1952. 18/–.

This volume should have a wide appeal to naturalists in particular and to lovers of the Scottish Highlands in general. Written in Seton Gordon's able style, it is a mixture of ornithology, history and folk lore arranged on a regional basis. Unity is given to these threads of Highland topics by the author's obvious, love of the animal and human life of the hills and glens. He is at his best in personal reminiscences of hill walks through the Cairngorms, investing particular routes, such as the Lairig Ghru, with personalities as he describes the life of ptarmigan, golden eagle and dotterel. Mention must be made of the excellent photographs and the folding map, notwithstanding the publishers' apologies, is better than most. K.W.

The North East Lowlands of Scotland. (County Books). John R. Allan. 14 × 22 cm. x + 262 pp. London. Robert Hale, Ltd. 1952. 18/–.

Although this book purports to cover the whole of the low-lying eastern fringe of Scotland from Kincardine to Caithness, it is, in effect, confined to the shoulder south of the Moray Firth which contains the counties of Aberdeen and Banff. The author's treatment of his various topics is unequal, but special mention must be made of the chapters on the agricultural development and fishing communities of the north east. These are an excellent account of rural change within the last 250 years, marred only by the lack of detailed reference to source material. The book is an informative and readable account of a somewhat isolated and little known region of Scotland. K.W.

Introduction to Africa. A selective guide to background reading. Library of Congress. European Affairs Div. 17·5 × 25 cm. ix + 237 pp. Washington. University of Washington Press. 1952. $2.00.

This is a descriptive bibliography containing brief accounts of at least 1,100 books and papers "selected to supplement the relatively small amount of

American literature on Africa and with choice directed to balance the views and to mold individual, subjective writings into a reasonably objective entity." The Editor, Helen F. Conover, seems to have done this very well. and to be even a useful guide to such a large literature is a considerable achievement. The book is arranged by territories with sub-divisions such as "general," "historical," "contemporary issues" and "native cultures"; there is an index of authors, serials, etc. There are many references to works in French and some in Portuguese and Spanish but not in Italian or German. Geographers will regret the last omission and also that of certain valuable papers in British periodicals; nevertheless they should find the book most useful. A.G.O.

Study of an African Swamp. Frank Debenham. 21 × 33 cm. 88 pp. London. Colonial Office. H.M.S.O. 1952. 20/–.

Discussing Lake Bangweulu in his earlier Report on British Tropical Africa*, Professor Debenham suggested that much of the basic information needed for the resolution of its hydrological problems could be collected by a suitable party of young men from the Universities. The fruition of this idea is described in the present Report, which records the work done by the author, Mrs. Debenham and three young Cambridge geographers in the Bangweulu swamps in the summer of 1949, a party from which the present reviewer had regretfully to withdraw at the last moment. The objectives were to trace the cause of persistent flooding of the inhabited Lunga Bank, to survey potential navigation routes and to investigate the possibilities of certain marginal areas for rice cultivation. Despite many difficulties and the limited success of certain plans and equipment, a most commendable programme of work was accomplished, and the account of this is enriched by much interesting general information about the swamps and their vegetation, the native inhabitants and the possibilities of development. The report is most readable, and is attractively illustrated. Apart from its innate value it is a stimulating example of what can be done at little expense by young geographers working under wise, imaginative and enthusiastic leadership.

* Report on the Water Resources of the Bechuanaland Protectorate, Northern Rhodesia, the Nyasaland Protectorate, Tanganyika Territory, Kenya and the Uganda Protectorate. London. Colonial Research Publications No. 2, Colonial Office, H.M.S.O., 1948. R.F.P.

Elton and the East African Coast Slave-Trade. Being extracts from the diary of Capt. James Elton. E. A. Loftus. 12 × 18·25 cm. v + 61 pp. London. MacMillan and Co., Ltd. 1952. 1/8.

These extracts from Captain James Elton's diary for the period 1873–6 reveal the spirit and purpose of those who worked to kill the East African slave-trade and indicate some of the obstacles that they had to face. They suggest the altruism with which the white man's burden was often shouldered during the nineteenth century. Elton's journeys took him to many coastal districts between Durban and Zanzibar and his vivid descriptions indicate both the geographical and the social conditions of the time. To the sketch-map might usefully be added more of the places that he visited. R.W.S.

How Nigeria is Governed. C. R. Niven. 12 × 18·5 cm. 164 pp. London. Longmans, Green & Co., Ltd. 1950. 4/6.

This book claims to be designed for the schools of Nigeria, but it contains far more than any normal school child could absorb. It is much more likely to attract the general public of Nigeria and even to become a handy reference book and guide to procedure for civil servants there.

Only the introductory historical-geographical sketch will interest the general reader in the United Kingdom, but for those specially concerned much geography can be gleaned. R.M.

Malaya. Text by G. Hawkins. Designed and illus. by C. A. Gibson-Hill. 19·5 × 26·75 cm. 114 pp. Singapore. The Government Printing Office. 1952. $5.

"Malaya is a land of such exquisite charm that the dull details of its geography should be recorded with no more fullness than is absolutely necessary." Opening with these words, this handbook proceeds to review in turn, very briefly, the colony of Singapore and each of the territories comprising the Federation of Malaya. The text is not only meagre, it consists of very light fare. Nor is it

really well written. The type is clear and only one misprint was noted (p. 8, "principal" for "principle"). Geographers seeking to extend their knowledge of the country and peoples of Malaya will turn elsewhere than this text, but teachers of the subject looking for pictorial illustrations will be grateful for the numerous well-produced photographs which, in fact, occupy most of the space in this handbook. A.V.W.

The Northern Sea Route, Soviet Exploitation of the North East Passage. T. Armstrong. $16 \cdot 5 \times 24$ cm. xiii + 162 pp. Cambridge. Cambridge University Press, Ltd. 1952. 21/–.

This volume, the first Special Publication of the Scott Polar Research Institute is a detailed, thoroughly documented, survey of "Soviet Exploitation of the North East Passage." Based almost entirely on Russian sources (only a handful of the 406 references are non-Russian), it gives the fullest and most up-to-date account of the efforts which have been made to establish a waterway along the northern shores of Eurasia. Part I deals with the history of the unco-ordinated attempts to open the Northern Sea Route before 1933. In that year, the Soviet Government embarked upon an extensive programme of Arctic development; hence Part II ("The Northern Sea Route from 1933 to 1949") is devoted to the concerted actions of Government Departments to increase the use of Soviet Arctic waters for both strategic and economic purposes; scientific investigation "assumed a routine character from 1933 onwards."

This work is clearly the result of careful and systematic research and will be of great value to all students of Arctic geography. A.E.M.

Taiwan (Formosa): A geographical appreciation. Foreign Geography Information Series No. 5. B. Shindman, for Dept. of Mines and Tech. Surveys, Geographical Branch, Canada. $21 \times 27 \cdot 25$ c.m. xi + 59 pp. Ottawa. Dept. of Mines and Technical Surveys. 1952. 50c.

The foreign geography reports prepared by the Geographical Branch of the Canadian Department of Mines and Technical Surveys are intended to make readily available to Canadians geographical data about foreign areas of importance to that nation. That Taiwan has been selected for special treatment is a reflection of recent events that have made it a likely major point of interest in the Far East. In a well balanced, concise and factual survey the salient characteristics of Taiwan's physical, economic and social geography are clearly presented and data as recent as 1949 are included. Full page maps supplement the text and particular aspects of the outline survey may be amplified by reference to a select textual and cartographic bibliography. N.P.

Alaskan Odyssey. B. R. Hubbard. $14 \cdot 25 \times 22$ cm. xii + 198 pp. London. Robert Hale, Ltd. 1952. 18/–.

Twenty-five years ago, Alaska was a remote outpost of North America, its future developments and strategic importance foreseen dimly and by few; a series of journeys made then by the author, known to Alaskans because of his exploits, as the Glacier Priest, with a varied succession of companions, are described in this short book. Father Hubbard's ascents of great volcanoes and treks across glaciers are in the tradition of those other Jesuit travellers before him, whose *Relations* are virtual epics of North America. Writing more in the mood of explorer than priest, the author displays a remarkable talent for describing that bizarre compound of Arctic cold and volcanic heat which is the landscape of parts of south-west Alaska. About two hundred photographs, often imperfectly reproduced, complete the picture given in this most interesting and exciting set of stories. A.MacP.

The Lost Woods. E. W. Teale. $15 \cdot 5 \times 23$ cm. 224 pp. London. Robert Hale, Ltd. 1952. 21/–.

This book, by an American author who is a natural philosopher in the Thoreau tradition and intensely interested in "the realm of nature," is very readable and excellently illustrated by the author's photographs. It is not intended to be strictly geographical but good descriptive writing and infectious enthusiasm nevertheless convey vividly to the reader a picture of some aspects of the American countryside. A wealth of interesting observations on animal, plant, bird and insect life, as well as on natural phenomena and landscape in a broader sense, adds to one's knowledge in a memorable manner, and bears the stamp of authenticity. L.S.

Freshwater Fish and Fishing in Native North America. Erhard Rostlund. University of California Publications in Geography, Vol. 9. 17 × 26 cm. x + 313 pp. Berkeley. University of California Press. 1952. $3·50.

One of the most neglected aspects of geography is that of inland fisheries. Statistics of sea fisheries, weight and value of catch landed, are freely available but any comparable data on freshwater fisheries are usually absent. Here, at last, is a thoroughly competent and comprehensive monograph covering the United States and Canada. The first third is geographical and assesses the value of what the author calls " the fish resource." It deals with the food value of freshwater fishes, the distribution of the principal species, the quantities available and a regional review. The second two-thirds deals with the various methods of catching, preserving and using fish employed by the aboriginal American Indians and is mainly of interest to the anthropologist. Collected together at the end of the volume, after an exhaustive bibliography, which occupies 34 closely printed pages, is a series of 47 fully annotated maps. These show the distribution of the chief species (including Pacific coast salmon) and the methods of fishing, but two general maps are of special geographical interest. One shows the quantity of fish available expressed in average annual production in pounds per square mile of territory. There is a range from over 800 lbs. per annum in the coastal rivers of both Atlantic and Pacific, to approximately nil in some of the desert basins. The area focusing on the Great Lakes and Lake Winnipeg is given as 400–600 lbs. The other is a map of " fish provinces " based on distribution of species. Apart from a large " Great Lakes Province " this shows a marked coincidence with main drainage provinces. L.D.S.

The Happy Island. Bengt Danielsson. 14 × 22 cm. 256 pp. London. Allen and Unwin, Ltd. 1952. 15/–.

The author was one of the complement of the Kon-Tiki raft which, after crossing the Pacific Ocean, made land on Raroia, a little known island of the Tuamotu archipelago. He liked it so much that he and his wife returned to live on the island. The islands are nominally French and no strangers are admitted, but baneful European influences are not unfelt. The archipelago has a bad name for shoals, reefs and occasional tornadoes. Many books have been written on South Sea idylls, but this one is noteworthy for its study of the natives, and appreciation of their point of view. It is a serious contribution to our knowledge of this isolated group of Polynesia. Mr. Danielsson liked the life, but, significantly, does not advise others to follow his example. R.N.R.B

Geography in the Making. J. K. Wright. 17·5 × 25·5 cm. xxi + 436 pp. New York. American Geographical Society. 1952. $5.00.

No one more fitting than Dr. J. K. Wright could have been chosen to write the history of the American Geographical Society and no one could have done it better. He has produced a very large work of more than 400 pages, has illustrated it with scholarly taste, and has supplied many notes and appendices to add to its value. The first four chapters, which take the story down to 1899, will appeal more particularly to the specialist, and have no outstanding interest for English readers. From then on, however, so many aspects of geography are treated that all interested in the development of the subject will find much of value and importance. To those who still like to ask " What is geography ? " and " What is a geographer ? " the comments on pages 269–70 may be particularly commended. Here, too, will be found many sidelights on the work of well known geographers who have contributed in one way or another to the work of the American Geographical Society. Moreover, the narrative is such that it becomes, for all practical purposes, a general sketch of the content of the subject. Part of the epilogue is worth quoting at length, both for its conclusions and as some indication of what the book contains.

" What is the geography that the Society has striven to advance ? We have not tried to answer this by adding another definition to the many that have been proposed, but have seen that geography, like Proteus, assumes different shapes and natures, which have something in common. It appears as a Science, to be developed through accurate observation and logical reasoning ; and also as an Educational Discipline. It takes the form of an Instrument of practical use to sailor and soldier, merchant, philanthropist, or statesman, and from this it emerges as a Guide pointing the way toward action. Throughout the ages it has appeared as Lore that brings delight through its appeal to the imagination

and poetic faculties. More accomplished than Proteus, geography may take two or more of these forms simultaneously. It is as difficult to define as Proteus was to grasp and hold.

"In the Society's publications geography has assumed all these forms at every period since the founding of the institution. Certain forms, however, were especially favored at different times. Until about 1895 geography appeared more often in the aspect of Lore than has since been the case. Not necessarily less respectable in this aspect than in others, it was by later standards more literary and less 'scientific.' Until 1895 it also frequently took the shape of an Instrument for practical use. Since 1895 it has figured as a growing Science. In that year it made its debut as an Educational Discipline, and it wore this face in many papers in the *Bulletin* until about 1915. During and since Dr. Bowman's administration, besides manifesting itself as a Science it has figured largely as a practical Instrument, sometimes as an Educational Discipline, and sometimes as a potential Guide toward the understanding and solution of problems of large human importance. And to-day it is appearing in these same forms, but with renewed power as an Educational Discipline." J.N.L.B.

Air Geography : A Global View. Thoburn C. Lyon. 19·5 × 25·5 cm. 60 pp. Toronto. D. Van Nostrand Co., Inc. (MacMillan and Co., Ltd.) 1952. 15/–.

Claiming to be a "brief summary of the whole field of geography," the chapter headings of this little book are a better guide to its scope. They are : Geography is Global ; the World acquires a third dimension ; Polar Geography, the Geography of Weather ; Geography as a Military factor. The impression left on the reader can be summed up in a sentence adapted from Chapter 2 : "they believed that the world was a globe with their own country in the middle." It is written from a frankly American viewpoint ; the information, however, is generally sound, if over-simplified, and it is a welcome sign that the author, who is president of Aeronautical Services, Inc., should have entered the field of geographical education. E.E.E.

The Nature and Properties of Soils. T. L. Lyon, H. O. Buckman and N. C. Brady. 15·5 × 23·25 cm. xvii + 591 pp. 5th ed. New York. MacMillan and Co., Ltd. 1952. 43/6.

This work is a descriptive study in applied pedology ; descriptive since comparatively few details of methods of soil analysis are given ; applied since emphasis is laid upon the soil in relation to agricultural techniques, such as the economic application of fertilisers. The authors suggest that they are examining the soil from the standpoint of the higher plant, but it is the cultivated plants which are most fully treated, and there is relatively little reference to natural vegetation or to the reciprocal effects of plants and soil. The full references to recent work, however, would greatly assist in extending study to these other aspects of pedology. The book is most clearly written and, as no assumptions are made as to the knowledge of chemistry and physics (other than the most elementary) possessed by the reader, it should prove extremely valuable to students, especially those reading bio-geography. Noteworthy in this respect are the chapters dealing with soil colloids and soil reaction. The relationship between soil reaction on the one hand, fungoidal and bacterial activity, and the availability of plant nutrients on the other, is well explained, and the diminution in the amount of available phosphates in neutral and alkaline soils (shown in the simple but clear accompanying diagram) is obviously an important point to be considered in any estimate of the fertility of our widespread chalk soils. Quite naturally many of the examples are American but this does not result in a loss of interest since European statistics (notably from Rothamsted) are also used. E.M.Y.

Manual of Phytogeography. L. Croizat. 15·5 × 24·5 cm. viii + 587 pp. 105 Maps. The Hague. W. Junk. 1952. 45 gld.

This massive volume of nearly six hundred pages traces the distribution of various orders and genera of plants throughout the world with the aim of reconstructing the distribution of land and water in time and space. The data are admitted to be inadequate and the book does not succeed in settling many problems, although it throws light on several questions. It must be regarded as a contribution to plant geography and in no sense a thorough solution to the problems involved. It is not a readable work but a source of reference for students. There are numerous outline maps. R.N.R.B.

Animal Ecology. C. Elton. 14 × 22·25 cm. xx + 209 pp. London. Sidgwick and Jackson, Ltd. 1951. 21/–.

During the last century, scores of natural history societies were cataloguing plants and animals and recording their occurrence in this and that area. Each plant or animal was regarded as a separate morphological unit with no reference to adjoining species or to physical surroundings. The work was useful in its day, for it helped in the accurate classification of species, but it was very limited in interest. This outlook has changed in the last thirty or fifty years, resulting either in the death of such societies, their work completed, or in a change to the ecological outlook, that is, the study of plants and animals as part of the environment as a whole. This began with plants and spread to animals. Thus a new and profoundly interesting science was founded. This is the third impression of a book first published in 1927. Additions have been made to every chapter and the bibliography is revised. Such a study cannot be exhausted in one small volume and there are bound to be omissions. For instance, one would like to hear more about seals and their ways, concerning several of whose species there are interesting links with the physical surroundings. But these are minor matters : the book is indispensable to all students of natural history and has many ideas and conclusions valuable to the geographer. Moreover it is readable throughout. R.N.R.B.

Zoogeography of the Land and Inland Waters. L. F. de Beaufort. 14 × 22·25 cm. viii + 208 pp. London. Sidgwick and Jackson, Ltd. 1951. 30/–.

This is primarily a zoological textbook but since it treats the distribution of animals and recognises major natural regions, it offers much of interest to the geographer. The more obvious correlations between environment and fauna of the present day are scarcely mentioned ; the author is more concerned with determining the factors which over long ages have established the present distribution of animals. Palæontology and past climates, particularly glacial, therefore receive much attention and it is fascinating to see how the zoological evidence, not normally familiar to geographers, corroborates that from geomorphology. The rivers of eastern England, for example, are related as regards their fauna to the Rhine and not to the west-flowing British rivers. There are ten maps and a bibliography. R.M.

Zoogeography of the Sea. S. Ekman. 14 × 22·25 cm. xiv + 417 pp. London. Sidgwick and Jackson, Ltd. 1953. 42/–.

This massive textbook of animal biology attempts to systematise our knowledge of the world distribution of marine creatures. Of necessity the present environment is often not enough to explain existing distributions. While the science of oceanography naturally bulks very large in the book, present and past climates and former faunas as evidenced by fossil forms are often invoked to explain otherwise anomalous distributions. In its methodology, zoogeography thus resembles plant geography and the special interest of the book is the way in which, in the present era of specialism, the author straddles scientific frontiers and indeed builds his subject out of a collaboration with other sciences. There are many maps and a large bibliography. R.M.

A German and English Glossary of Geographical Terms. Eric Fischer and Francis E. Elliott. 13·5 × 20·9 cm. vii + 111 pp. New York. American Geographical Society. 1950. $3.

In view of the importance and impressive size of geographical literature in German and the fact that until now there has been no technical German–English dictionary covering the subject, this book represents a courageous and long overdue beginning. It is to be hoped that its extensive use will soon encourage an enlarged and thoroughly revised edition, since it is clearly only a beginning in size as well as in purpose and manner of compilation. The following criticisms, though inevitably selective, are directed towards such improvement and are in no way intended to detract from the merit and usefulness of this book.

Within little over 100 pages, equally divided between the German-English and English–German parts, it purports to cover a field of research developed enormously within the last 80 years. In doing this, it addresses itself to the American rather than the English user. One result is that many familiar English terms are omitted, even when these offer a shorter translation. Thus *Tagebau*

could be rendered "opencast mining," *abgegangener Ort* "waste settlement," *Ausflugskarte* "tourist map," *Autobahn* "motorway," *Hochwald* "high forest," *Kessel* "kettle," *Hochmoor* "raised bog," *Schneise* "forest ride," *Wohnung* "dwelling." Nor do the compilers make use of simple English expressions such as "shot" or "furlong" for *Gewann*, "allotment" for *Schrebergarten* ("allotments" for *Laubenkolonie*), "relative relief" or "ruggedness" for *Reliefenergie*. Moreover the American meaning of English terms used in this glossary is often quite different from the English one. Similarly on the German side, South German and Austrian expressions tend to dominate over the more generally used Central and North German ones.

More important, however, is the question of scope. A cursory perusal of the index lists in German works (especially standard textbooks) suggests that this glossary is not only manifestly too small but also uneven in its emphasis on various systematic aspects of geography. Thus, relatively, geomorphology has been over-emphasised to the extent of giving some of the technical terms coined by Walter Penck whereas *e.g.*, human geography and perhaps cartography appear inadequately and less competently dealt with. In human geography, in particular, the "geopolitics" of the brief Nazi era loom rather large whereas settlement geography in which German research has offered substantial contributions in the past is less well represented.

Some terms of fundamental importance to the geographer are missing, such as *geographische Lage*, *Ortslage*, *Landschaftsgliederung*, *schütter*. The glossary also omits important systematic terms like *Anthropogeographie* (not equivalent to the English "anthropogeography"), *Siedlungsgeographie*, *Wirtschaftsgeographie* cartographical terms like *Spezialkarte*, the many compounds of *Diagramm* and *Kartogramm*, *Schrägbild*, *Senkrechtbild*, terms in human geography like *Bevölkerungsdichte* (more correct than *Volksdichte !*), *Wirtschaftsformation*, *Kultursteppe*, *Stadtrandzone*, *Wohndichte*, *Mietshaus* and *Mietskaserne* (more generally used than the southern *Zinshaus*), *Mietswohnung*, *Einfamilienhaus*, *Bebauung* *Vereinödung*, and the English "smallholding" and "smallholder." "Slum" is, *Elendsviertel*, and "blighted area" (English "depressed area") is *Notstandsgebiet*. Sometimes, within one category, some terms are given but not others. Thus, amongst trees, *Buche*, *Esche*, *Fichte*, *Kiefer*, amongst roof forms *Giebeldach*, *Pultdach*, *Satteldach* have been omitted. The rendering of many German terms is partly or wholly infelicitous as in the case of *Lagebeziehung*, *Halbinsellage*, *Flussdichte*, *Taldichte*, *Talweg*, *Vorort*, *Betriebsform*, *Runddorf*, *Waldhufendorf*, *Halbwalmdach*. "Settlement pattern" is not *Siedlungsform* but *Siedlungsgefüge* or *Siedlungsstruktur*. *Einstöckiges Haus* is "single-storey house" or "bungalow," *zweistöckiges Haus* is "two-storey house."

Some of the problems of glossary compilation are indicated by these criticisms, but all of them can be eventually solved by a more universal approach including all systematic aspects of geography and using the best available textbooks and specialist reference works. M.R.G.C.

Practical and Experimental Geography. W. G. V. Balchin and A. W. Richards. 17 × 21·5 cm. viii + 135 pp. London. Methuen and Co., Ltd. 1952. 12/6.

From time to time, over a number of years, teachers of geography have published information about exercises and models that have facilitated understanding of aspects of the subject. There are many other ideas for visual aids in use which have not appeared in print. This book is a first attempt to gather together many of these suggestions and to supplement the existing body of practical aids by the inclusion of teaching methods that have been originated by the authors themselves. The result is a very interesting and useful handbook for teachers. Understandably the value of models is found to be greatest in teaching those parts of the subject that are concerned with the earth's movements and their effects, land forms, the atmosphere and the oceans, but there are also descriptions for the construction of simple survey instruments and a model to demonstrate perspective map projections. The last section in the book is a summary of the main categories of distribution maps and diagrams and contains some practical constructional methods for producing good results. The book is excellently produced and the diagrams beautifully drawn. It is to be hoped that teachers will accept the invitation in the preface to contribute additional ideas, or suggestions for improvement upon those already described, so that the existence of these teaching aids may be widely known. N.P.

How the First Men Lived. The First Great Inventions. How the World was Explored. Marie Neurath and J. A. Lauwerys. 20 × 22cm. 36 pp. London. Max Parrish & Co., Ltd. 1952. 6/– (boards) each.

Visual History of Mankind Series. 1, Living in Early Times. 2, Living in Villages and Towns. 3, Living in the World. 1-3, Notes for the Teacher. M. Neurath and J. A. Lauwerys. 20 × 21·5 cm. 49 pp. London. 2nd Edition. Max Parrish & Co., Ltd. 1950. 3/6 each.

The interest of these books is mainly historical but for the geography teacher, especially in Primary schools, they contain much that is relevant and illuminating. They are all well produced, clearly printed, vividly illustrated and, above all, reliable. We can recommend them for the use of teachers and for the most able of the Primary school children. We hesitate however to recommend them for more general use in Primary schools. The background of knowledge and range of vocabulary assumed in these books is not that one expects to find, except in rare cases, among Primary school children. Consequently, the narrative in the first group and the questions which form the text of the second group, admirable though they are for maturer minds, are, we believe, too difficult for most Primary school children. The symbolic diagrams which form so large, important and striking a part of these books contain difficulties in interpretation as far as children are concerned. Primary school children are, at best, only mastering the art of reading. To appreciate these series they have to master a new symbol language to which, incidentally, no key is provided. The diagrams further assume a mastery in the interpretation of small scale maps which is not usual in Primary schools. PRIMARY SCH. SECT. COMMITTEE.

Fundamental Geography Series. General Editor, L. Brooks. **Book 1. Many People in Many Lands.** D. M. Forsaith. **Book 2. The Earth in Making.** E. M. Coulthard. **Book 3. Climate, Vegetation and Man.** L. Hadlow. 14 × 21·5cm. 208 pp., 256 pp., 288 pp., London. University of London Press, Ltd. 1952. Bks. 1 and 2, 6/–. Bk. 3, 8/6.

This is a new series of texts for Grammar School pupils, soundly written by an able and experienced team. *Fundamental Geography* discards the common practice of teaching by countries or regions and each volume takes the world as its parish. In Book I Miss Forsaith has gathered a truly remarkable collection of typical local studies taken from varied parts of the home country, Commonwealth and foreign lands. By an intriguing selection of plans, maps and pictures supported by most readable descriptions, she portrays the lives of individual people as influenced by their geographical environment, making an admirable introduction to serious geographical study for first year pupils in any type of secondary school.

In Book 2 Miss Coulthard sets out to " put the ' Ge ' into geography " and does it most effectively. All types of rock structure and land forms are considered and illustrated by well-chosen diagrams, maps and pictures. The human element is never lost sight of, and the influence of physical geography upon life and work and even upon history is well brought out.

In Book 3 Mr. Hadlow outlines a careful and comprehensive study of the elements of climate, profusely illustrated by good diagrams. He goes on to portray the influence of climatic conditions upon world vegetation and man's response to both in the various ' natural regions ' of the world. If the book may prove a little difficult for some third year pupils they will return to it with profit in later years.

Good and often ingenious questions and exercises at the end of each chapter are a feature, while paper, printing and binding are excellent. All this is of course rather expensive, but it is hoped that many schools will be able to afford to introduce the series, or, at least, to place copies in pupils' and teachers' libraries. C.B.T.

Geographical Articles in Magazines Received.

CONTINUED FROM VOL. XXXVIII, pp. 52 to 54.

Journals listed here may be borrowed from the Library by members of the Association. References are listed according to the classification published in the *Annals of the Association of American Geographers*, Vol. XXVII, June, 1937.

A of G—Annals of the Association of American Geographers. A of Sc—Advancement of Science. BGB—Bulletin de la Societé de Géographie de Beograd. CGR—Geographical Review of India (formerly Calcutta Geogr. Review). EG—Economic Geography. GA—Geografiska Annaler. GJ—Geographical Journal. GN—Geografiska Notiser. GR—Geographical Review. IGJ –Indian Geographical Journal (formerly Journal of Madras Geog. Assoc.). J of G—Journal of Geography. LER—Les Etudes Rhodaniennes. LS—Lund Studies. RGA—Revue de Géographie Alpine. RGI—Rivista Geografica Italiana. SGA—Svensk Geografisk Årsbok. SGM—Scottish Geographical Magazine. T—Terra. TPR—Town Planning Review.

(E)—English Summary. (F)—French Summary. (G)—German Summary. *—Map.

GENERAL GEOGRAPHY AND TRAVEL. M. AUROUSSEAU, GJ, Jne. '52.—What is an English geographical name ? J. N. L. BAKER, A of Sc, Mar. '52.—Development of Historial Geography in Britain during the last hundred years. BRITISH ASSOC. GEOGR. GLOSS. COMMITTEE, GJ, Jne., Sept. '52.—Some definitions in the vocabulary of geography. A. DAVIES, GJ, Sept. '52.—" First " voyage of Amerigo Vespucci in 1497–98. P. E. JAMES, A of G, Sept. '52.—Towards a further understanding of the regional concept. S. B. JONES, GR, Oct. '52.—Enjoyment of Geography. R. N. RUDMOSE BROWN, SGM, Dec. '52.—Fifty years ago : the Scottish National Antarctic Expedition. J. K. WRIGHT, GJ, Jne. '52.—British geography and the American Geographical Society, 1851–1951. G. M. WRIGLEY, GR, Oct. '52.—Adventures in Serendipity : thirty years of the *Geographical Review*.

MATHEMATICAL GEOGRAPHY AND CARTOGRAPHY. W. APPLEBAUM, EG, July '52.—Technique for constructing a population and urban land use map. E. M. J. CAMPBELL, IGJ, Jub. Vol. '52.—Lehmann's contribution to the cartographical alphabet. G. H. DURY, IGJ, Jub. Vol. '52.—Methods of cartographical analysis in geomorphological research. A. J. HUNT, TPR, Oct. '52.—Urban population maps. H. SILCOCK, TPR, Jan. '53.—Sampling and the census. B. W. SPARKS, GJ, Mar. '53.—Effects of weather on the determination of heights by aneroid barometer in Great Britain. C. S. SPOONER, GR, Jan. '53.—Modernisation of terrain model production.

PHYSICAL GEOGRAPHY. E. BAILEY, A of Sc, Jne. '52.—Hundred years of geology. C. A. COTTON, GJ, June. '52.—Erosional grading of convex and concave slopes. W. O. FIELD, and C. J. HEUSSER, GR, July '52.—Glaciers—historians of climate. C. R. LONGWELL, and H. E. HINTON, A of Sc, Mar. '52.—Continental drift. M. MARKGREN, SGA, '52.—Land-ice divides : problems, methods, results (E). A. H. W. ROBINSON, SGM, Sept. '52.—Floor of the British Seas. B. A. TATOR, A of G, Dec. '52.—Pediment characteristics and terminology.

CLIMATE. N. ANANTAPADMANABHAN, CGR, Jne. '52.—Sea conditions associated with a cyclone in the Bay of Bengal. S. B. CHATTERJEE, CGR, Sept. and Dec. '52.—Precipitation characteristics (India). R. T. CORNISH, IGJ, Jub. Vol. '52.—Air mass studies and regional climates. A. COURT, GR, Jan. '53.—Temperature extremes in the United States. A. GARNETT, IGJ, Jub. Vol. '52.—Relief, latitude and climate : some local consequences. K. KRAMES, GA, Heft. 3–4, '52.—Temperatur- und Niederschlagsanomalien im Sommer der Nordhemisphäre. A. A. MILLER, IGJ, Jub. Vol. '52.—Month-degrees as a measure of accumulated temperatures. E. ROSTLUND, J of G, Oct. '52.—Persistent planetary-wind diagram. A. R. SUMNER, GR, Jan. '53.—Standard deviation of mean monthly temperatures in Anglo-America.

HUMAN GEOGRAPHY. H. C. BROOKFIELD, IGJ, Jub. Vol. '52.—Geographical study of the urban sprawl of western cities. S. P. CHATTERJEE, CGR, Jne. '52.—Food shortage. K. M. D. DAUNCEY (Ed.), A of Sc, Jne. '52.—Ancillary aids to archeaology : report of symposium. G. EVANS, A of Sc, Jne. '52.—Land settlement problems in undeveloped areas. A. FORREST, A of Sc. Jne. '52.—Origin of Life. D. B. HARDEN (Ed.), A of Sc, Mar. '53.—Lab, techniques in archaeology (symposium). O. H. JOHNSON, SGA, '52.—Migration and birthplace field of a town : formula (E). R. LAWTON, IGJ,

Jub. Vol. '52.—Geographical analysis of population movements. LER, No. 3, '50.—Etudes urbaines. LER. No. 4, '50—Etudes villageois. J. M. MAY, GR, Jan. '53.—Map of the world distribution of leprosy*. J. M. MAY, GR, Oct. '52.—Map of the world distribution of plague*. J. M. MAY, and S. WALSH, IGJ, Jub. Vol. '52.—Medical geography : programme of studies of the American Geographical Society. A. SESTINI, RGI, July '52.—Human geography—land use and cultural divisions (E). T. S. SIMEY, TPR, Jan. '52.—Dynamic cities. G. VEYRET-VERNER, RGA, Pt. IV, '52.—Types de régimes démographiques-essai d'interprétation géographique.

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